Complementors as Innovation Ecosystem Actors: Interactions, Capabilities, Challenges

Carst, Alexandra Elena

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COMPLEMENTORS AS INNOVATION ECOSYSTEM ACTORS

INTERACTIONS, CAPABILITIES, CHALLENGES

BY
ALEXANDRA ELENA CARST

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AALBORG UNIVERSITY
DENMARK

Complementors As Innovation Ecosystem Actors

Interactions, Capabilities, Challenges

Ph.D. Dissertation

Alexandra Elena Carst

AALBORG UNIVERSITY
DENMARK

Dissertation submitted May 2023

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PhD supervisors: Associate Professor Yimei Hu,
Aalborg University

Professor Ping Lv,
University of Chinese Academy of Sciences

PhD committee: Associate Professor Dmitrij Slepniov (chair)
Aalborg University

Associate Professor Agnieszka Radziwon
Aarhus University

Professor Xielin Liu
University of Chinese Academy of Sciences

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Abstract

Innovation ecosystems have become a critical area of research due to their potential to foster innovation and growth. Complementors—value-adding actors who contribute to the ecosystem's core value proposition—have emerged as important actors in innovation ecosystems, mainly due to their value enhancement role. However, the literature on complementors in the ecosystem setting remains limited in terms of their interactions, capabilities, and challenges, with inconsistent understanding in different types of ecosystems. The interplay of cooperation and competition between complementors and other ecosystem actors can create tensions and challenges that threaten the stability and performance of the ecosystem.

This thesis aims to answer the following main research question: How do complementors manage the interplay of cooperation and competition dimensions in an innovation ecosystem? This research question is addressed across four papers that comprise the body of this thesis. The four papers explored different aspects of complementors in innovation ecosystems. Paper I reviews the relevant ecosystem literature and provides an overview of the concept of complementors in the ecosystem context. It also identifies various research gaps and provides research directions for complementors' coopetitive interactions, strategies, and challenges in ecosystems.

Along with the systematic review on complementors, each empirical paper uses a case study approach, drawing on qualitative data primarily collected through interviews with complementors and other actors in the innovation ecosystem of wind energy.

Paper II focuses on the dynamism of complementors' interactions in an innovation ecosystem and the drivers of change that shift the dimensions of these interactions. Using multiple case studies of eight Danish wind energy complementors, this study reveals that most wind energy complementors engage in coopetitive interactions with focal firms, despite an apparent unawareness or conscious dismissal of the competitive dynamic involved. This study emphasizes the dynamism and complexity of complementors' interactions as ecosystem actors.

Paper III examines complementors' capabilities in dealing with dynamic interactions in the wind energy ecosystem. Through multiple case studies, this study identifies several capabilities that complementors rely on, such as adaptability, networking, sensing, seizing, transforming, ecosystem thinking, balancing sharing and secrecy, and coopetition capability, to cope with ecosystem evolution and technological trends, maintain their position and competitive advantage, ensure compatibility with the focal offer, and deal with coopetitive tensions.

Paper IV explores how complementors deal with complement challenges that may evolve into bottlenecks and threaten the ecosystem's health and development. Using the insights of two ports in Denmark and China, which act as complementors in the offshore wind energy ecosystem, this study reveals that complementors rely on several approaches, such as compliant collaboration, sub-ecosystem building, alignment pursuance, and position leveraging, to deal with complement challenges. The choice of coping approach is contingent on the complexity of complement challenges and complementors' willingness to comply.

Overall, this PhD thesis contributes to expanding our knowledge of complementors in innovation ecosystems by providing a comprehensive understanding of their strategic roles, interactions, capabilities, and approaches to dealing with complement challenges. The findings have implications for complementors, focal firms, and other ecosystem actors, as well as for policymakers and practitioners seeking to foster innovation and collaboration in innovation ecosystems by engaging with complementors.

Resumé

Innovationsøkosystemer er blevet et kritisk forskningsområde på grund af deres potentiale for at fremme innovation og vækst. Komplementorer, værdiskabende aktører, der bidrager til økosystemets kerneværdiforslag, er dukket op som vigtige aktører i innovationsøkosystemer – hovedsageligt på grund af deres værdiforstærkende rolle. Imidlertid er litteraturen om komplementorer i økosystemet stadig begrænset med hensyn til deres interaktioner, evner og udfordringer. Derudover hersker en inkonsistent forståelse i forskellige typer af økosystemer. Samspillet mellem samarbejde og konkurrence mellem komplementorer og andre økosystemaktører kan skabe spændinger og udfordringer, der truer stabiliteten og præstationen af økosystemet.

Denne afhandling sigter mod at besvare følgende hovedforskningsspørgsmål: Hvordan håndterer komplementorer samspillet mellem samarbejds- og konkurrence-dimensioner i et innovationsøkosystem? Dette forskningsspørgsmål behandles i fire artikler, der udgør kernen af denne afhandling. De fire artikler undersøger forskellige aspekter af komplementorer i innovationsøkosystemer. Artikel I gennemgår den relevante litteratur om økosystemer og giver et overblik over begrebet komplementorer i økosystemets kontekst. Artiklen identificerer også forskellige forskningshuller og giver forskningsretninger for coopetitive interaktioner, strategier og udfordringer af komplementorer i økosystemer.

Udover den systematiske gennemgang af komplementorer, anvender hver empiriske artikel en casestudie metode, der bygger på kvalitative data, primært indsamlet gennem interviews med komplementorer og andre aktører i vindenergiens innovationsøkosystem.

Artikel II fokuserer på dynamikken i komplementorernes interaktioner i et innovationsøkosystem og på de driver, der skifter dimensionen af disse interaktioner. Ved at bruge flere casestudier af otte danske vindenergi-komplementorer afslører denne undersøgelse, at de fleste vindenergi-komplementorer engagerer sig i coopetitive interaktioner med fokalfirmaer, på trods af en tilsyneladende uvidenhed eller bevidst afvisning af den konkurrenceprægede dynamik, der er involveret. Denne undersøgelse understreger dynamikken og kompleksiteten af komplementorernes interaktioners, som økosystemaktører.

Artikel III undersøger komplementorernes evner til at håndtere dynamiske interaktioner i vindenergiøkosystemet. Gennem flere casestudier identificerer denne undersøgelse flere evner, som komplementorer er afhængige af, såsom tilpasningsevne, netværksdannelse, sansning, seizing, forvandling, økosystemtænkning, balancering af deling og hemmeligholdelse, og coopetition-evne for at klare økosystemets udvikling og teknologiske tendenser, fastholde deres position og konkurrencefordel, sikre kompatibilitet med den centrale forslag og håndtere coopetitive spændinger.

Artikel IV udforsker, hvordan komplementorer håndterer komplementære udfordringer, som kan udvikle sig til flaskehalse og true økosystemets sundhed og udvikling. Ved at bruge indsigter fra to havne i Danmark og Kina – der fungerer som komplementorer i offshore-vindenergiøkosystemet – afslører denne undersøgelse, at komplementorerne er afhængige af flere tilgange, såsom overensstemmende samarbejde, opbygning af underøkosystemer, tilpasningsforfølgelse og udnyttelse af positionen for at håndtere komplementære udfordringer. Valget af håndteringsmetoden er afhængigt af kompleksiteten af komplementære udfordringer og komplementorers vilje til at samarbejde.

Samlet set bidrager denne ph.d.-afhandling til at udvide vores viden om komplementorer i innovationsøkosystemer ved at give en omfattende forståelse af deres strategiske roller, interaktioner, evner og tilgange til at håndtere komplementære udfordringer. Resultaterne har betydning for komplementorer, fokalfirmaer og andre økosystemaktører, samt for politiske beslutningstagere og praktikere, der søger at fremme innovation og samarbejde i innovationsøkosystemer ved at engagere sig med komplementorer.

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The completion of this thesis would not have been possible without the invaluable support and guidance of numerous individuals, to whom I extend my sincere thanks.

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Thesis Details

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Thesis submitted:	May 2023
Ph.D. Candidate:	Alexandra Elena Carst
Supervisors:	Associate Professor Yimei Hu, Aalborg University Professor Ping Lv, University of Chinese Academy of Sciences

The main body of this thesis consist of the following papers.

[I] Alexandra Elena Carst and Yimei Hu, "Complementors as Ecosystem Actors: A Systematic Review," *Submitted for publication*, 2023.

[II] Alexandra Elena Carst, "Complementors' Interactions in the Wind Energy Ecosystem: Dynamics, Coopetition, and Drivers," *Submitted for publication*, 2023.

[III] Alexandra Elena Carst and Yimei Hu, "Complementors' Capabilities in Innovation Ecosystem: Dealing with Dynamic Interactions in the Wind Energy Ecosystem," *DRUID23 Conference Proceedings*, Lisbon, June 2023.

[IV] Alexandra Elena Carst and Ping Lv, "How Complementors Deal with Complement Challenges: A Comparative Study of Ports in the Wind Energy Ecosystem," *International Journal of Technology Management* [Forthcoming], 2023.

This thesis has been submitted for assessment in partial fulfillment of the PhD degree. The thesis is based on the submitted or published scientific papers which are listed above. Parts of the papers are used directly or indirectly in the extended summary of the thesis. As part of the assessment, co-author statements have been made available to the assessment committee and are also available at the Faculty. The thesis is not in its present form acceptable for open publication, but only in limited and closed circulation, as copyright may not be ensured.

Preface

As I began my PhD journey, I was excited to embark on a research project that would take me to China to explore various innovation ecosystems. My original plan was to dive into the diverse and dynamic Chinese market, studying complementors in multiple ecosystems across different industries. However, as the world came to a standstill due to the COVID-19 pandemic, so did my plans. The sudden halt in travel and on-site research forced me to rethink and refine my research focus.

I had to embrace the unpredictability of the situation, adapt, and remain flexible, just like the actors in innovation ecosystems who must constantly navigate complex and changing circumstances. As I navigated the uncharted waters of a pandemic-affected academic journey, my thesis became more focused, centered on a single ecosystem that I am passionate about, namely, the wind energy ecosystem.

The academic journey of a PhD is full of uncertainties and challenges, and no amount of preparation or planning could have foreseen its unpredictability. It has been a humbling experience that has allowed me to grow both personally and professionally. Despite the added challenges due to COVID-19 restrictions, this journey has taught me invaluable lessons about the characteristics of innovation ecosystems and the importance of resilience and adaptability in the face of uncertainty. With no blueprint to follow, I had to carve my own path, using a combination of project management skills, determination, and the guidance of my esteemed advisors.

Through this thesis, I hope to shed light on the importance of complementors in innovation ecosystems, to offer insight into how they navigate complex and dynamic interactions with other actors, and to inspire future research in this exciting field. My own experience has taught me that flexibility, adaptation, and continuous innovation are key to success in any innovation ecosystem but also in a PhD journey.

Alexandra Elena Carst

Aalborg University, May 5, 2023

Part I

Synopsis

1 Introduction

In recent years, there has been growing interest in understanding the dynamics of innovation ecosystems – complex settings where firms, institutions, and other actors work together to create new and more complex products and services (Adner, 2017; Adner & Kapoor, 2016b; Jacobides et al., 2018). Innovation ecosystems consist of a network of loosely coupled actors, such as focal firms, component suppliers, complementors, universities, government agencies, and other organizations that interact with each other to create, develop, and commercialize new innovations (Adner, 2017; Jacobides et al., 2018; Tsujimoto et al., 2018). Within these ecosystems, complementors are essential actors who provide complementary innovations aimed at enhancing the value or benefit of a core product (Brandenburger & Nalebuff, 1996; Teece, 1986). Complementors have been recognized as playing an essential role in shaping the dynamics of innovation ecosystems, as they can influence the success or failure of the focal firms, they support (Adner, 2012, 2021; Brandenburger & Nalebuff, 1996). The added value of incremental innovations to a core product is undeniable. Furthermore, complementors' interactions with the focal firm(s) and other actors in the ecosystem are crucial for the success of the innovation ecosystem (Adner, 2012; Adner & Kapoor, 2010; Brusoni & Prencipe, 2013; Kapoor & Agarwal, 2017; P. J. Williamson & De Meyer, 2012). Nonetheless, do focal firms or other ecosystem actors really understand these third-party providers?

Various industries across the globe are heading towards a progressive change where ecosystem settings are embraced to deliver complex and sophisticated innovations: *"It's competition among business ecosystems, not individual companies, that's largely fueling today's industrial transformation"* (Moore, 1993, p. 76). Innovation ecosystems create the proper environment where players collaborate to create new value, incorporate integral outputs, and deliver a more advanced and refined innovation portfolio (Iansiti & Levien, 2004b; Li et al., 2019; Walrave et al., 2018; P. J. Williamson & De Meyer, 2012). For these reasons, there is a growing interest in studying and understanding ecosystems both in the practitioners' world and academic circles (Burström et al., 2023; Fuller et al., 2019; Granstrand & Holgersson, 2020; Randhawa et al., 2020; Shipilov & Gawer, 2020; Tsujimoto et al., 2018). Ecosystems require inputs from diverse stakeholders with varying degrees of technological proximity to the users, making collaboration and interaction among these ecosystem actors essential for creating value (Dattée et al., 2018; Dedehayir et al., 2022; M. G. Hoffmann et al., 2022). However, the complementors hold the power of differentiation and the source of full value potential (Cenamor, 2021; Hilbolling et al., 2020; Yoffie & Kwak, 2006).

Through their value-adding innovations, complementors are critical to the core value proposition of the ecosystem and subsequently to the success and health of the focal firm and the entire ecosystem (Adner, 2012; Adner & Lieberman, 2021; Brandenburger & Nalebuff, 1996; Shipilov & Gawer, 2020). In many ecosystem studies, complementors are

defined as *consumers* due to their downstream position (Gawer, 2014). However, some researchers also consider them downstream innovators since their small, incremental innovations are added value to the focal firm's offering (Adner, 2006; Cusumano & Gawer, 2002). The role and presence of complementors in such settings are deemed necessary for the focal firm(s) and the overall ecosystem (Adner & Kapoor, 2010; Brusoni & Prencipe, 2013). For instance, software applications provided by third-party developers are critical to the performance of operating systems, such as Android by Google and iOS by Apple (Kapoor & Agarwal, 2017; Schaarschmidt et al., 2019). Coordinating with complementors and ensuring compatible complements translates not only in higher benefit for the customers but also timely adoption of the core offering (Adner, 2012, 2021).

Despite their importance to the activity and growth of the focal firm, the latter has (almost) no control or influence on the former, no fair understanding of them, or practically no receptivity to complementors (Adner & Kapoor, 2010; Cennamo & Santaló, 2019; Kapoor, 2013, 2018). Regardless of these perceptions, understanding complementors is essential in overcoming certain risks they may pose (Inoue, 2019; Mantovani & Ruiz-Aliseda, 2016; Ozalp et al., 2018). These challenges arise from various differences between them and the focal firm in connection to their knowledge base or goals (Adner & Kapoor, 2010; Boudreau, 2012; Eckhardt et al., 2018; F. Zhu & Iansiti, 2012). Additionally, the focal firm(s) cannot manage or coordinate complementors in the same way they use with suppliers because there is no official link between the focal firm(s) and complementors (Adner, 2012; Adner & Kapoor, 2010; Adner & Lieberman, 2021; Jacobides et al., 2018). Moreover, their downstream position, as illustrated in Figure 1, contributes to complementors' neglect by focal firms (Adner, 2012, 2021). For example, even though Airbus developed the impressive passenger aircraft A380, the lack of coordination with airports that would have to accommodate such aircraft affected its commercialization (Adner & Kapoor, 2010). The same happened with Alfa Romeo and Fiat during their first attempt to enter the USA market. Not engaging with complementors, such as qualified mechanics and spare parts shops, led to failed expansion (Brandenburger & Nalebuff, 1996). Thus, complementors require tailored approaches in interacting and coordinating with them.

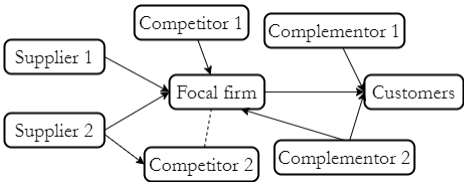

Figure 1. Schematic figure of a generic innovation ecosystem (Informed by Adner & Kapoor, 2010).

Despite the acknowledged importance of complementors in innovation ecosystems, their management of the (coexistence of) cooperation and competition dimensions in their relationships remains a challenging issue (Deilen & Wiesche, 2021; Yoo et al., 2022; F. Zhu, 2019). This research gap is particularly problematic because complementors often

operate in complex and rapidly changing environments, such as innovation ecosystems, where (the interplay of) competition and cooperation can be difficult to manage (Bacon et al., 2020; Basole, Park, et al., 2015; Hannah & Eisenhardt, 2018; Struckell et al., 2021; Wegmann et al., 2018; Yoo et al., 2022). In order to thrive, complementors need to balance their cooperative activities with competition and manage the inherent tensions that arise in their relationships with focal firms (Inoue, 2019; Yoffie & Kwak, 2006; Yoo et al., 2022). While some research has investigated how complementors can be managed or coordinated (Boudreau & Jeppesen, 2015; Hilbolling et al., 2020; Kapoor, 2013; Wang & Miller, 2020; Yoffie & Kwak, 2006), there is a lack of systematic understanding of how cooperation and competition dimensions are navigated in innovation ecosystems from the complementors' perspective.

With a game theory origin, complementors were first coined in Brandenburger and Nalebuff's "Co-opetition" book (1996). Although the original definition recognized complementors as carrying competitive tensions in their interactions, the ecosystem literature has mainly emphasized the complementors' collaborative nature and value-adding role (Boudreau, 2010; Scholten & Scholten, 2012; Srinivasan & Venkatraman, 2010; Tsujimoto et al., 2018). This has led to an overlook of the competitive dimension and the risks involved in interactions with complementors in ecosystems (Mantovani & Ruiz-Aliseda, 2016; Yoo et al., 2022; F. Zhu & Liu, 2018). Studies on the interactions that involve complementors are minimal and predominantly from the focal firm's vantage point, particularly in the platform ecosystem context (Kapoor, 2013; Tavalaei & Cennamo, 2021; F. Zhu, 2019; F. Zhu & Liu, 2018). The ecosystem stream has been dominated by the focus on focal firms or, at most, how the focal firms can control complementors or invade their market space (Kapoor, 2013; Yoffie & Kwak, 2006; F. Zhu, 2019; F. Zhu & Liu, 2018). By studying complementors, we can gain insights into how to manage the cooperation and competition dimensions of innovation ecosystems, which is essential for creating and capturing value. Exploring the complementors' perspective over these interactions can uncover a different but complementary angle of the ecosystem story.

1.1. Motivation and Objectives

This thesis aims to explore and enhance our understanding of the cooperative and competitive dynamics that take place in an ecosystem by taking the vantage point of complementors, a rather overlooked yet value-adding type of ecosystem actor.

The increasing uncertainty that companies are facing nowadays can be tackled more easily in ecosystem settings where various partners collaborate through loosely interconnected relationships (Iansiti & Levien, 2004b; Li et al., 2019; P. J. Williamson & De Meyer, 2012). This statement relies on the ecosystem advantages and potential of pooling knowledge from various sources, speeding up learning, developing joint innovations, and fast commercialization with high degrees of customization for the benefit of users (Adner, 2006, 2012; Adner & Kapoor, 2016b; Rohrbeck et al., 2009). Moreover, complementors allow focal firms to access the benefits posed by their innovations and capabilities

without vertically integrating them, which cannot be fully or properly transferred through an M&A, for instance (P. J. Williamson & De Meyer, 2012). Timely ensuring compatible complements translates into *"the extent to which the offer can create value for users"* (Adner & Kapoor, 2010, p. 312).

While complementors can create positive network effects and foster innovation (Awano & Tsujimoto, 2022; Boudreau & Jeppesen, 2015; Clements & Ohashi, 2005; Srinivasan & Venkatraman, 2010), they can also pose challenges to focal firms in terms of coordination and competition (Adner & Kapoor, 2010, 2016a; Inoue, 2019; Leavy, 2012; F. Zhu & Liu, 2018). The availability, delivery, and versatility of complements to a focal offer result in the enhanced attractiveness of the latter (Adner, 2012; Adner & Kapoor, 2010). However, neglecting complements limits the value of a product that users can generate and delays adoption, thereby affecting the competitive advantage of the focal firm (Adner & Kapoor, 2010; Brandenburger & Nalebuff, 1996; Ethiraj, 2007). Therefore, understanding how complementors manage cooperation and competition dimensions in innovation ecosystems is crucial for achieving sustainable and effective innovation outcomes (Cennamo et al., 2018; Jacobides et al., 2018).

Although complementors and their innovations are critical to the viability of the focal firms, the latter often focus more on solving component challenges rather than complement challenges (Adner & Kapoor, 2010). The former refers to the difficulties that arise in coordinating and integrating the different upstream components within an ecosystem. Complement challenges refer to the difficulties posed to and by complementors that threaten the timely delivery or development of the focal offer. While both challenges can evolve into bottlenecks, their impacts differ. Upstream challenges *"limit value creation by constraining the focal firm's ability to produce its product, downstream complement challenges limit value creation by constraining the customer's ability to derive full benefit from consuming the focal firm's product"* (Adner & Kapoor, 2010, p. 310). Due to a lack of formal agreements or different knowledge bases (Jacobides et al., 2018; Kapoor, 2013, 2018), complementors cannot be directly controlled by focal firms (Brusoni & Prencipe, 2013). Although collaborating with complementors is highly beneficial for the focal firm(s) and the entire ecosystem (Adner, 2017; Kapoor, 2013; Kapoor & Agarwal, 2017), complementors' perspective in this collaboration and their ecosystem participation has not been properly uncovered.

The ecosystem literature has shed more light on the focal firms' perspective in dealing with orchestration, coordination challenges, or entering complementary market spaces (Autio, 2021; Kapoor & Lee, 2013; Leavy, 2012; Yoffie & Kwak, 2006; F. Zhu & Liu, 2018), setting the complementors aside (Kapoor, 2013). The vantage point of focal firms that dominates ecosystem studies may differ from complementors' perceptions and motivations (Holgersson et al., 2018; Kapoor, 2013). Understandably, upstream suppliers and their derived component challenges have also received more attention due to the focal firm's direct dependency (Adner & Kapoor, 2010; Huo et al., 2022). However, without complementors' innovations, focal firms cannot reach their full potential for

success (Adner, 2012; Shipilov & Gawer, 2020). Therefore, the present thesis aims to provide an in-depth understanding of complementors.

Previously, companies solely emphasized gathering feedback from their customers (Balka et al., 2014; Bogers & West, 2012; Iyer & Henderson, 2012; Panico & Cennamo, 2020), but subsequently, there was a shift towards including their suppliers as well (Letaifa, 2014; Wilhelm & Sydow, 2018). Although the practice of attending to complementors is still in its early stages, considering and incorporating complementors expands the previously mentioned practices of companies (Brandenburger & Nalebuff, 1996; Hermalin & Katz, 2011; Reiss, 2011). This dissertation aims to contribute to this angle. To achieve these objectives, this thesis incorporates a systematic review of the existing literature on complementors in innovation ecosystems, followed by three empirical studies that focus on different aspects of complementors' management of cooperation and competition dimensions in innovation ecosystems, i.e., the dynamics of interactions, capabilities, and (approaches to) challenges. For each paper, the research gap and objective are elaborated in Table 1.

Paper	Research gap	Objective
Paper I	Unclear definition and characteristics of complementors, differentiation between intersecting concepts, i.e., complements, complementary assets, complementarity	Understand the development of complementors as ecosystem actors
Paper II	The focus on cooperative dynamics in complementors' interactions led to overlook of their competitive dynamics	Investigate the dynamism of their interactions and drivers of change
Paper III	Lack of understanding regarding complementors' capabilities in dealing with the complexity of their ecosystem interactions	Explore the capabilities that complementors adopt to deal with challenges assumed by their dynamic interactions in innovation ecosystems
Paper IV	Complementors' approach to dealing with complement challenges has been overlooked, while focal firms have been studied as the sole responsible party to solve such challenges in ecosystems	Investigate the approaches complementors employ in coping with complement challenges

Table 1. Research gaps and objectives of the four papers.

1.2. Research Questions and Delimitations

The main research question for this thesis is: *How do complementors manage the interplay of cooperation and competition dimensions in an innovation ecosystem?* This overarching question is divided into the following sub-questions:

1. *How are complementors understood in the ecosystem context?*
2. *How do complementors navigate the tensions between cooperation and competition in innovation ecosystems?*
3. *How do complementors cope with complement challenges?*

Although the focal firm's perspective dominates the development of the ecosystem literature, this thesis focuses on the downstream perspective of complementors, unlocking a different vantage point that contributes to the ecosystem story. The order of the sub-questions follows a logical progression that builds upon each other. The first sub-question sets the foundation by defining and identifying who the complementors are in the ecosystem context in Paper I. The second sub-question explores how complementors navigate the tensions between cooperation and competition, which is a crucial aspect of their role(s) and participation in the ecosystem. Complementors have to cooperate with a wide range of actors in the ecosystems, e.g., focal firms, complementors, and customers, while simultaneously competing with or for them, which creates a unique set of challenges. Building upon these challenges, the third sub-question is proposed, focusing on how complementors cope with complement challenges. Complement challenges represent an extreme set of difficulties that are on the verge of becoming bottlenecks (Adner & Kapoor, 2010). These challenges are the focus of the third sub-question answered in Paper IV. Complement challenges are thus different from the regular challenges that complementors face in their interactions within an ecosystem, which are touched upon in Papers II and III. These challenges stem from or are related to their interdependence with other actors in the ecosystem, complementors' contributions to the ecosystem, intensity of competition, or even coopetition dynamics, and so on.

To address the research questions of this thesis, this dissertation will empirically focus on complementors in the wind energy ecosystem (WEE). The choice of the empirical context for Papers II, III, and IV, i.e., WEE, is motivated not only by its suitability to the topic of this thesis but also by the novelty of taking an ecosystem perspective to study wind energy. This industry has been dominantly explored by theories and frameworks such as innovation systems, supply chain management, and sustainability. Furthermore, the complementors have been rather neglected in this context until now. While the insights gained from this research may have broader implications for other innovation ecosystems, the focus is limited to the wind energy context. The ecosystem's boundary is delimitated in this thesis to the downstream of the value chain of the ecosystem's proposition. Thus, the actors involved and considered in the study are mainly complementors, focal firms, customers, experts, universities, organizations, and two component suppliers. However, their upstream insights are rather restricted in this thesis due to their limited connection with complementors, the targeted actors for this research.

Furthermore, the study is restricted to complementors that provide hardware, software, and services directly to the focal value proposition. While there are certainly other complementors in this ecosystem, these complementors were selected based on their strategic importance and representativeness. Another boundary regarding complementors is the disregard of their suppliers due to the obvious cooperation dimension in their interactions, except for complementor G's case presented in Paper II.

	Title	Co-authors	Research question
Paper I	Complementors as Ecosystem Actors: A Systematic Review	Yimei Hu	(1) What are complementors' characteristics and role(s) in ecosystems? (2) How do complementors behave in the ecosystems? (3) How are the intersecting concepts understood in ecosystem literature?
Paper II	Complementors' Interactions in the Wind Energy Ecosystem: Dynamics, Coopetition, and Drivers	-	How do complementors' interactions evolve in an innovation ecosystem, and what are the drivers of change that shift the dimension of these interactions?
Paper III	Complementors' Capabilities in Innovation Ecosystem: Dealing with Interaction Challenges in the Wind Energy Ecosystem	Yimei Hu	What capabilities complementors, as innovation ecosystem actors, rely on to address the ecosystem challenges posed by their dynamic interactions?
Paper IV	How Complementors Deal with Complement Challenges: A Comparative Study of Ports in the Wind Energy Ecosystem	Ping Lv	How do complementors deal with complement challenges in an innovation ecosystem?

Table 2. Overview of papers and their research questions included in the thesis.

1.3. Overview of Papers

To address the research question, this thesis presents a systematic review of the literature on complementors as ecosystem actors and three empirical articles that examine complementors in the WEE. Table 2 provides an overview of the paper titles and research questions.

Paper I is a systematic review that aims to clarify the development of complementors' research in the extant ecosystem literature. It provides a more comprehensive and in-depth understanding of the definitions, roles, and interactions of complementors in ecosystems by answering the first sub-question: How are complementors understood in an ecosystem setting? This question is further broken down into three research questions for Paper I: (1) What are complementors' characteristics and roles in ecosystems?, (2) How do complementors behave in the ecosystem?, and (3) How do the intersecting concepts overlap in ecosystem literature?

Paper II is an exploratory multiple case study of eight Danish complementors in the WEE that seeks to understand the dynamics of complementors' interactions with various ecosystem actors and identify the drivers of change from one interaction dimension to another. This study aims to answer the following questions: (1) How do complementors' interactions evolve in an innovation ecosystem?, and (2) What are the impacting drivers of change? This study aims to demonstrate the complex nature of complementors in an innovation ecosystem context, beyond their collaborative nature, which is rendered by their main role of value enhancement to the ecosystem's core value proposition.

Paper III relies on a multiple case study of the same eight WEE Danish complementors as Paper II to identify the capabilities complementors rely on in their interactions to cope with their implied challenges. The paper aims to answer the following question: What capabilities complementors, as innovation ecosystem actors, rely on to address ecosystem challenges posed by their dynamic interactions?

Paper IV is a comparative study of two ports that act as complementors in the WEE in Denmark and China. The paper aims to identify the ports' approaches to dealing with complement challenges that threaten to become bottlenecks to the ecosystem by answering the following research question: How do complementors deal with complement challenges in an innovation ecosystem?

Each of the four papers included in this thesis contributes to answering one or more of the sub-questions that comprise the main research question of the dissertation, as illustrated in Figure 2. Paper I explores the first sub-question of the thesis by examining the characteristics and roles of complementors in ecosystems, their behavior, and the intersection of concepts in ecosystem literature. The identified findings and research gaps have implications for the following two sub-questions. Paper II addresses the second sub-question of the thesis by investigating how complementors' interactions evolve in an innovation ecosystem and the drivers of change that shift the dimension of these interactions. Paper III also connects to the second sub-question, but from a different angle, by exploring the capabilities that complementors rely on to address common challenges posed by their dynamic interactions. The identified capabilities may have implications for dealing with complement challenges (i.e., potential bottlenecks in the ecosystem). Finally, Paper IV examines the third sub-question of the thesis by identifying complementors' approaches to deal with complement challenges in an innovation ecosystem. Considering that interactions with various ecosystem actors are essential in this situation, the identified coping strategies also have implications for the second sub-question.

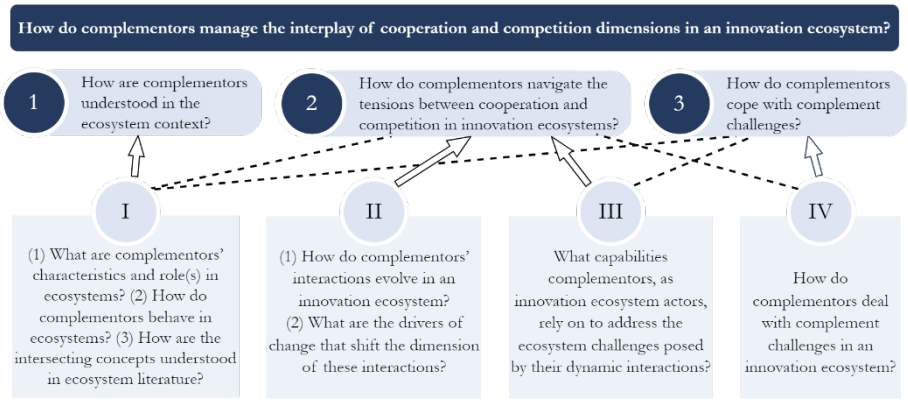

Figure 2. Connection between the research questions of the thesis and the four papers.

1.4. Structure of the Dissertation

The structure of the present thesis is as follows. Section 2 provides an overview of the theoretical and conceptual constructs that are relevant to the logics of each paper included in this dissertation. Section 3 describes the methodological considerations, including the research strategy of each study, the empirical context, and the details of data collection and analysis. The four papers are presented in self-standing chapters in the body of the thesis, with each paper occupying a separate section from Section 4 to 7. Finally, Section 8 offers an overall discussion of the key findings from the four studies, along with their theoretical and practical implications, as well as limitations and suggestions for future research.

2 Theoretical and Conceptual Background

"The whole is greater than the part" (Euclid[1])

In this section, the broader theoretical and conceptual perspectives of the thesis are elaborated. The first part introduces the definitions, features, and interactions of innovation ecosystems. A subsection on the three dominant perspectives of ecosystems follows, i.e., ecosystem as affiliation, structure, and coevolution. The last part focuses on complementors and their links with coevolutionary logics.

Open approaches to creating innovation are increasingly common in a world driven by fierce competition, modularity, and interdependence (Chesbrough, 2003). Developing increasingly complex value propositions requires various resources, knowledge, and capabilities that can be accessed by aligning heterogeneous, autonomous actors (Gnyawali & Park, 2009). Innovation ecosystems provide nurturing settings in which different actors join forces to create a complex innovation that would otherwise have been difficult to develop in-house (Adner, 2006; Bacon et al., 2020; Dattée et al., 2018).

Innovation ecosystems have become a popular topic in innovation research due to their ability to facilitate the creation and commercialization of innovative products and services (Adner, 2017; Feng et al., 2019; Gomes et al., 2018; M. G. Hoffmann et al., 2022; Letaifa, 2014; Zahra & Nambisan, 2011). Recent conceptual developments in the innovation ecosystem have contributed to its maturity while detaching itself from its precursor, the business ecosystem (Foguesatto et al., 2021; Moore, 1993). Ecosystems provide a setting for firms to collaborate and co-create value, as well as access a wide range of resources and expertise that may not be available within the firm itself (Bogers et al., 2019). This can lead to the development of more complex and sophisticated innovations, as well as a competitive advantage for participating firms (Shipilov & Gawer, 2020; G. Xu et al., 2018).

The concept of *innovation ecosystems* has garnered attention due to its ability to expand our understanding of *"the networked nature of innovation and entrepreneurship"* through its metaphor association (Ritala & Gustafsson, 2018, p. 53). While research on innovation systems has managed to change the emphasis from individual agents to *"the links and interactions between the various actors"* (Martin, 2016, p. 435), empirical studies on innovation ecosystems seem to take on the challenge of researching developments in the world and foci such as sustainability and services (Alaimo et al., 2020; Boyer, 2020; Chandler et al., 2019; Fasnacht, 2018; Inoue, 2019; Z. Liu & Stephens, 2019; Lütjen et al., 2019).

The present thesis focuses on complementors, the actors that differentiate ecosystems from value chains (Kindermann et al., 2022; Thomas & Autio, 2019). Complementors

[1] A common variation usually credited to Aristotle is *"The whole is greater than the sum of its parts."*

are actors whose products and services are bundled with the focal firm's offering (Adner, 2006; Brandenburger & Nalebuff, 1996; Jacobides et al., 2018). This joint consumption generates a higher benefit for the user. Although located downstream of the focal firm's position, complementors can impact the value creation-capture in the ecosystem (Adner, 2017; Jacobides et al., 2018; Teece, 1986).

2.1. Innovation Ecosystems: Definitions, Features, and Interactions

Innovation ecosystems play a crucial role in fostering innovation and economic growth (Ferasso et al., 2018). However, the concept of innovation ecosystem is still evolving and lacks a universally accepted definition or framework for understanding its features and interactions. The term *ecosystem* is polysemous, with multiple definitions depending on the context in which it is applied. Nevertheless, it is expected that *"ecosystems as arrangements of interdependent value creation will only grow in prevalence and in importance in the years to come"* (Adner, 2017, p. 56).

The term *ecosystem* originates from ecology (Jackson, 2011; Tansley, 1935). Its inherent dynamism and complex nature determined Moore (1993) to introduce *ecosystem* in the management literature, suggesting that *"a company be viewed not as a member of a single industry but as part of a business ecosystem that crosses a variety of industries"* (ibid., p. 76). The business ecosystem, as coined by Moore, refers to a complex network of organizations, individuals, and technologies that foster innovations through cooperation and competition (ibid.). Sharing a common purpose, the members of a business ecosystem evolve *"from a random collection of elements to a more structured community,"* just as in nature (ibid., p. 76). However, Moore's seminal article focused on delivering an ecological approach to studying and understanding a company, rather than providing an explicit definition of a business ecosystem (Moore, 1993; Thomas & Autio, 2019).

Since then, the concept has been refined and expanded by scholars and practitioners to encompass a wide range of industries, regions, and applications, such as innovation ecosystems (Adner, 2006, 2017), platform ecosystems (Cusumano & Gawer, 2002; Gawer & Cusumano, 2002, 2014), entrepreneurial ecosystems (Autio et al., 2014; Spigel & Harrison, 2018), knowledge ecosystems (Clarysse et al., 2014; Valkokari, 2015; van der Borgh et al., 2012), service ecosystems (Lusch et al., 2016; Lusch & Nambisan, 2015). However, these developments have preserved the definition issue (Ferasso et al., 2018; Gomes et al., 2018; Oh et al., 2016; Shipilov & Gawer, 2020).

2.1.1. Definitions of the (Innovation) Ecosystem

In academia, innovation ecosystems are considered more than a buzzword applied in the business world; instead, it is mainly used as a metaphor or an analogy that explains a *phenomenon* (Ritala & Gustafsson, 2018). Innovation ecosystems are seen as the proper conditions for nurturing internationally viable innovation (Adner, 2017), as they involve various loosely coupled actors coming together to create a common value proposition

(Bogers et al., 2019). Innovation ecosystems can be perceived as a hybrid between knowledge ecosystems and business ecosystems because the innovation ecosystem incorporates the exploration of new information, knowledge, and technology (knowledge ecosystems) and the exploitation of value creation for customers (business ecosystems), or better said, value co-creation (Valkokari, 2015).

The multiple definitions for innovation ecosystems emphasize different elements or characteristics (Thomas & Autio, 2019). Adner (2006) presented the first attempt to define the innovation ecosystem as *"the collaborative arrangements through which firms combine their individual offerings into a coherent, customer-facing solution"* (p. 2). The emphasis is placed on collaboration among different actors that contribute to a common value co-creation goal. However, in the strategy field, another definition provided by Adner (2017) prevails: *"the alignment structure of the multilateral set of partners that need to interact in order for a focal value proposition to materialize"* (p. 40). The focus of these definitions falls on a shared purpose that creates agreement among ecosystem participants in terms of roles, positions, and contributions, i.e., the alignment structure (Adner, 2017; Cobben et al., 2022). Alignment among heterogeneous actors is necessary to ensure the common goal of co-creating the ecosystem's core value proposition, but formal alliances are not required, as the autonomy of actors is (and should be) maintained (Adner, 2006, 2017, 2021; Huo et al., 2022).

Recent innovation ecosystem studies highlight the idea that value co-creation results from complex relationships among heterogeneous yet interdependent actors (Adner, 2017; Dedehayir et al., 2022; Gomes et al., 2022; M. G. Hoffmann et al., 2022; Kapoor, 2018). This indicates that interactions are key to understanding the underlying dynamics and complexities inherent in innovation ecosystems. This perspective aligns with the view that innovation ecosystems are characterized by multilateral interdependence and non-generic complementarities, value proposition and creation, as well as the coexistence of competitive and cooperative ties (Adner, 2017; Adner & Kapoor, 2010; Gomes et al., 2018, 2021; M. G. Hoffmann et al., 2022; Jacobides et al., 2018; Kapoor, 2018).

Non-generic complementarities are one of the differentiating features of innovation ecosystems, and Jacobides et al. (2018) emphasized this construct in defining the ecosystem as *"a set of actors with varying degrees of multilateral, nongeneric complementarities that are not fully hierarchically controlled"* (p. 2264). As an ecosystem type, innovation ecosystems can be defined as "*the evolving set of actors, activities, and artefacts, and the institutions, and relations, including complementary and substitute relations that are important for the innovative performance of an actor or a population of actors"* (Granstrand & Holgersson, 2020, p. 1). Ritala and Almpanopoulou (2017) highlighted the features of interdependence, co-creation, and coevolution in describing ecosystems. Innovation ecosystems are thus characterized by a set of interrelated features and elements that contribute to their effectiveness in fostering innovation. The following subchapters will explore some core characteristics of ecosystems.

2.1.2. Dynamism and Coevolution of Ecosystems

Many academics agree that all the actors in an innovation ecosystem are suppliers of knowledge (Fransman, 2014) and are interlinked through the final value proposition. The complexity of the system increases with the number of different components involved. Understanding an ecosystem does not only resume to the participating actors, but should be viewed as a whole, including the complicated interactions between its members (Phillips & Ritala, 2019). Upstream components are essential for the product of the focal firm(s). However, complementors can also be categorized under *"direct value creation roles"* together with suppliers (Dedehayir et al., 2018, p. 18). The diversity and heterogeneity of ecosystem actors determine the complex interactions that impact the development and delivery of innovation.

One of the key features of innovation ecosystems is their dynamism, which refers to the level of change within an ecosystem over time. Dynamism implies their ability to constantly adapt and evolve in response to changing market conditions, new technologies, and regulatory environments (Alaassar et al., 2021; Basole, Russell, et al., 2015). This dynamism, rendered by continuous change, uncertainty, and unpredictability, requires a flexible and adaptive approach to innovation management. Furthermore, ecosystem dynamism is nurtured by the interactions among multiple and heterogeneous actors in the ecosystem, which enable the exchange of information, knowledge, and resources (Iansiti & Levien, 2004b; Y. Xu et al., 2021). Due to their dynamism and evolving nature, ecosystems are not temporally or spatially bounded compared to other collaborative concepts, such as alliances, business networks, value chain, and business models (Aarikka-Stenroos & Ritala, 2017; Lusch et al., 2016). Moreover, ecosystems' lack of full hierarchical control, compared to other collaborative concepts, fuels their dynamism, implying that ecosystem actors and activities are constantly evolving and adapting (Cobben et al., 2022; Jacobides et al., 2018; Kapoor, 2018). Therefore, innovation ecosystems are dynamic and non-linear.

A closely related concept to dynamism and its generative source is coevolution, which refers to the mutual adaptation or interdependence of the various actors triggered by changes in the ecosystem or a participant (Adner & Kapoor, 2010; J. Chen et al., 2016; Dedehayir et al., 2022; Shou et al., 2022). These changes initiate and shape other changes, creating a feedback loop that drives the evolution of the two elements (Kauffman, 1993; Ritala et al., 2020; Ritala & Almpanopoulou, 2017; Volberda & Lewin, 2003). Coevolution is facilitated by technology interconnectivity and interactions among actors, which enable them to learn from each other and adjust their strategies and behaviors accordingly (Aarikka-Stenroos & Ritala, 2017; J. Kim et al., 2022; Oh et al., 2016). Coevolution thus incorporates interdependence, mutual influence, and co-adaptation among ecosystem actors (Adner, 2012, 2021; Adner & Kapoor, 2010). Furthermore, coevolution captures the ecological approach of innovation ecosystems as dynamic systems in which actors' actions and decisions impact and are impacted by each other over time (Iansiti & Levien, 2004a; Ritala et al., 2013; Ritala & Almpanopoulou, 2017). The perpetual coexistence of

cooperation and competition dimensions in innovation ecosystems is absorbed by coevolution (Gomes et al., 2018; Moore, 1993).

2.1.3. Interdependence and Complementarity

Interdependence and complementarity are both distinctive features of innovation ecosystems that compensate for the lack of formal agreements among loosely coupled actors (Adner & Kapoor, 2010; Gomes et al., 2018; M. G. Hoffmann et al., 2022; Jacobides et al., 2018; Thomas & Autio, 2019). Borrowing from biological and evolutionary analogies, another key feature of innovation ecosystems is interdependence between actors rendered by coevolution (Adner & Kapoor, 2010; J. Chen et al., 2016; Ritala & Almpanopoulou, 2017). While coevolution emphasizes the dynamic and adaptive nature of the interactions between actors, interdependence emphasizes the mutual reliance of actors on structural relationships (Aarikka-Stenroos & Ritala, 2017; Adner & Feiler, 2019; Adner & Kapoor, 2010; Kapoor, 2018). Together, these concepts capture the complex, interrelated, and evolving nature of innovation ecosystems.

Interdependence refers to the degree of mutual reliance among actors for their survival and success in an innovation ecosystem (Adner & Kapoor, 2010; J. Chen et al., 2016; Ganco et al., 2020; Gomes et al., 2021; Jacobides et al., 2018). The activities of any single organization cannot be considered in isolation. Instead, they are embedded in an entire network of interdependencies, where change in one part of the ecosystem can have far-reaching, and often unexpected, effects in other parts of the ecosystem (Adner & Kapoor, 2010; Kang et al., 2011a; Leavy, 2012; Zhang et al., 2022). The involved agents are locked in the dependence created by common tasks, generating interdependent relationships (Aarikka-Stenroos & Ritala, 2017). Interdependence is driven by the complementary roles and resources that actors bring to the ecosystem to contribute to the core value proposition and can take various forms, such as cooperation, competition, or coopetition (Iansiti & Levien, 2004b; Moore, 2006; Velu, 2015). In this interlinked environment of complex interactions (Iansiti & Levien, 2004b), *"companies co-evolve capabilities around a new innovation: they work cooperatively and competitively to support new products, satisfy customer needs, and eventually incorporate the next round of innovations"* (Moore, 1993, p. 76). This interdependence between actors and their innovations leads to coevolution of the individual participants and the entire ecosystem (Hou & Shi, 2021; Inoue, 2019; Leavy, 2012; Rietveld et al., 2020; Ritala et al., 2020; Shou et al., 2022). Having a common goal encourages interdependencies among loosely coupled ecosystem participants (Aarikka-Stenroos & Ritala, 2017; Adner, 2017; Gawer & Cusumano, 2014; Wareham et al., 2014). Interdependence can also create a sense of collective responsibility for the success of the ecosystem as a whole (Adner, 2017; M. G. Hoffmann et al., 2022; Russo-Spena et al., 2017; Velu, 2015). However, interdependence may also impact other actors' *"ability to create value"* (Adner & Feiler, 2019, p. 111), the ecosystem's development and success in the form of co-innovation risks and adoption chain risks (Adner, 2006, 2012).

Interdependence coexists with complementarities in ecosystems (Cobben et al., 2022; Jacobides et al., 2018; Kapoor, 2018). Complementarity, as the glue of economic activities within an ecosystem, refers to the degree to which actors within an ecosystem bring different skills, resources, or capabilities that complement each other (Jacobides et al., 2018; Kapoor, 2018). Complementarity implies that the strengths of one actor can compensate for the weaknesses of another, resulting in a more effective and efficient innovation ecosystem (Gomes et al., 2018). As a defining element, multilateral nongeneric complementarities can be categorized into unique and supermodular (also known as Edgeworth) complementarities. The former assumes a certain level of co-specialization, while the latter manifests downstream (Jacobides et al., 2018; Teece, 1986; Venkatraman & Lee, 2004). Nongeneric complementarities suggest that, despite the undeniable presence of competitive dynamics in the ecosystem to capture value, the existence of alignment contributes to ecosystem success that also translates into profit and other benefits (Adner, 2017; Jacobides et al., 2018).

As the degrees of mutual reliance and difference among actors, interdependence and complementarity contribute to the functioning and success of innovation ecosystems, influencing their assumed interactions among heterogeneous and autonomous actors by adding to their complexity.

2.1.4. Interaction Complexity – Coopetition

Ecosystem actors interact to create and capture value from developed innovations. Value creation is enabled by cooperation between the various players, while value capture takes place at the company level by using their competitive advantage to derive profit (Khademi, 2020; Ritala et al., 2013). Being part of an innovation ecosystem and the intense cooperation between the participating actors goes beyond a common bilateral alliance or joint venture (Porter, 1985). Collaboration between businesses to create innovation affects their value chain by co-creating and exchanging value. Thus, the value creation process can take place at the entity level as well as the inter-player level (Radziwon et al., 2017).

Cooperation is key to materializing a specific innovation or a common value proposition in ecosystems. This cooperation enhances hyperconnectivity and networking among the participants of an innovation ecosystem as well as the empowerment of startups (Fasnacht, 2018). Thus, the interactions between the different actors and entities of an innovation ecosystem render its characteristics of dynamism and collaboration. These interactions also promote knowledge sharing, contribute to co-creating value, and deliver more complex and sophisticated value propositions than individual businesses, which can still manufacture independent products and/or services (Zahra & Nambisan, 2011). However, the complexity captured by ecosystem interactions poses various challenges. Coordination and cooperation between the various actors and entities involved represent one such challenge. This requires effective communication and trust, as well as the establishment of clear roles and responsibilities, despite the lack of formal agreements

(Gobble, 2014; M. G. Hoffmann et al., 2022). Additionally, the process of value creation and capture within innovation ecosystems can be complex and may require careful management to ensure that all parties involved are fairly compensated for their contributions (M. G. Hoffmann et al., 2022; Ritala et al., 2013).

The symbiotic relationships between the multitude of heterogeneous actors in innovation ecosystems can be cooperative to co-create value, but also competitive to capture value from each other's innovations (Cusumano & Gawer, 2002; Huang et al., 2019). Although the concept of innovation ecosystem has evolved to focus more on value (co-)creation and collaboration (Adner, 2017; Gomes et al., 2018, 2021; Granstrand & Holgersson, 2020; M. G. Hoffmann et al., 2022), the predecessor *business ecosystem* included both interaction logics, i.e., cooperation and competition, in the initial definition: *"In a business ecosystem, companies […] work cooperatively and competitively to support new products, satisfy customer needs, and eventually incorporate the next round of innovations"* (Moore, 1993, p. 76). Hence, cooperation and competition coexist in ecosystems to create knowledge and innovation (Bacon et al., 2020; Facin et al., 2016; Fasnacht, 2018; Fernandez et al., 2018; Gomes et al., 2018). In this context, coopetition has emerged as a strategic behavior and a shaping force of the complex interactions among ecosystem actors (Bengtsson & Kock, 1999; Brandenburger & Nalebuff, 1996; Le Roy et al., 2018). Although numerous definitions concur that coopetition refers to the coexistence of cooperation and competition logics (Bengtsson & Kock, 2000; Le Roy et al., 2018), the simultaneity of these two dimensions is questioned due to the paradoxical pursuit of cooperation and competition (Ritala et al., 2016). The former dimension entails common goals and benefits from value co-creation, while the latter assumes pursuing one's own goals and opportunistic behavior in capturing value (Bengtsson et al., 2016; Bengtsson & Kock, 2000; Ritala et al., 2013). Traditionally, coopetition scholars consider coopetition to be cooperation between competitors in a dyadic relationship between two companies (Bengtsson & Kock, 2000; K.-H. Kim, 2020). However, coopetition is multidimensional and multifaceted, referring to multiple actors that compete in some markets/projects while cooperating in other areas (Dorn & Albers, 2018; Hannah & Eisenhardt, 2018; K.-H. Kim, 2020). This perspective may be more in line with approaching coopetition as a duality of interdependent or interwoven contradictory logics of cooperation and competition, rather than as a separation of the two paradoxical forces that fails to capture the coopetitive dynamics (Andriopoulos & Lewis, 2009; Bengtsson et al., 2016; Gnyawali et al., 2016; K.-H. Kim, 2020; Rai et al., 2022).

The coopetition phenomenon has been increasingly researched, particularly in certain contexts, such as dyadic relationships, strategic alliances, business networks, and industries (Bengtsson & Kock, 1999, 2000, 2014; Bouncken & Kraus, 2013; Ranganathan et al., 2018; Ritala et al., 2016). Despite the incipient focus on value creation and cooperation in innovation ecosystems (Gomes et al., 2018; Granstrand & Holgersson, 2020), recent coopetition studies have expanded its scope to ecosystems (Bacon et al., 2020; Hannah & Eisenhardt, 2018; Wegmann et al., 2018), such as exploring the focal firms' perspective in balancing value creation and value capture or identifying the benefits

and challenges of coopetition (Ansari et al., 2016; Basole, Park, et al., 2015; Ritala et al., 2013). However, in these studies, the broader impact of coopetition on the innovation ecosystem is neglected, showing a deep potential for research in this context.

In ecosystems, the presence of contrasting dynamics is facilitated by the co-habitation of various actors, e.g., suppliers, focal firm(s), complementors, competitors, governments, industry associations, and educational institutions (Shipilov & Gawer, 2020). The relationships formed are complex and sometimes even tensed, which, in turn, render the dynamism of ecosystems and fosters a dynamic environment for creativity and innovation (Bengtsson & Kock, 2014; Zahra & Nambisan, 2011). Coopetition enables firms to pool their resources, share risks and costs, and overcome limitations and innovation-related challenges, such as complexity, ambiguity, and uncertainty, by sharing risks and costs (Bouncken & Kraus, 2013; Gnyawali & Park, 2009). Additionally, coopetition allows ecosystems to achieve superior performance and competitive advantage (Hannah & Eisenhardt, 2018). Coopetition literature also argues that an organization's innovativeness and competitive advantage can be augmented through partnerships and interactions shaped by coopetitive logics (Bacon et al., 2020; Bouncken & Kraus, 2013; Gnyawali & Park, 2009).

Coopetition is an inherent phenomenon in ecosystems depicted by interdependencies among actors (Basole, Russell, et al., 2015; Dorn & Albers, 2018; Kapoor, 2018; Malherbe & Tellier, 2022; Moore, 2006; Ritala et al., 2013; Wegmann et al., 2018). The interweaving of cooperation and competition interweave in ecosystems that render dynamic interactions is consistent with the coevolution and dynamism features of ecosystems (Hannah & Eisenhardt, 2018). However, the added complexity of the coopetition dimension governed by the ecosystem's coevolution and the needed capabilities deserves further research attention in the dynamic and complex environments of innovation ecosystems (Adner, 2006; Ansari et al., 2016; Bacon et al., 2020; Hannah & Eisenhardt, 2018; W. Hoffmann et al., 2018; Moore, 1996; Ritala et al., 2013, 2014; Wegmann et al., 2018). Furthermore, there is a lack of research on how complementors engage in coopetition with other ecosystem actors. Notable exceptions are provided by the platform ecosystem stream, where the focal firm's perspective still dominates (Argyres et al., 2022; Inoue, 2019; Wang & Miller, 2020; Yoffie & Kwak, 2006; Yoo et al., 2022; F. Zhu & Liu, 2018).

2.2. Ecosystem as Affiliation, Structure, Coevolution

Beyond the increasing typology of ecosystems that emphasize different foci or contexts expanding the boundaries of firms and industries (Aarikka-Stenroos & Ritala, 2017), ecosystems can be viewed and examined from different perspectives: ecosystem as affiliation, structure, and coevolution. These three approaches are elaborated below, explaining their emphasis in regard to the elements and characteristics of ecosystems.

2.2.1. Ecosystem as Affiliation

The ecosystem-as-affiliation approach emphasizes the association of actors with the focal firm(s) or platform(s) (Adner, 2017). Due to its focus on the connections of ecosystem actors to the focal firm(s), this approach dominates studies on business ecosystems (Adner, 2017; Jacobides et al., 2018; Moore, 1993). Ecosystem as affiliation also aligns with Moore's (1996) depiction of business ecosystems as "*an economic community supported by a foundation of interacting organizations and individuals – the organisms of the business world*" (p. 26). Thus, ecosystem actors are typically defined by their connections to the focal firm(s), which, in turn, determine the actors' positions in the ecosystem (e.g., components supplier, complementor, and customer), reflecting a firm-centric vision (Adner, 2017).

Despite breaking the boundaries of industries by recognizing the effect of interdependence and symbiotic connections among actors, this approach places great emphasis on network-related issues, such as density, centrality, number of participants, as well as concerns related to ecosystem entry, access, and openness (Adner, 2017). However, ecosystem studies relying on this approach have been criticized for heavily relying on the focal firm's perspective in connection with the aforementioned issues (Adner, 2017; Hou & Shi, 2021). Thus, the affiliation of ecosystem actors to the focal firm is often taken at face value.

To address these criticisms, some scholars have developed alternative approaches that shift the focus away from the focal firm(s) and onto the ecosystem's structure and activities, which are elaborated below (Adner, 2017; Ganco et al., 2020).

2.2.2. Ecosystem as Structure

The ecosystem-as-structure approach provides an alternative view to the traditional ecosystem-as-affiliation perspective and highlights the importance of the activities required for a value proposition to materialize (Adner, 2017; Ganco et al., 2020). This structuralist approach is *"an activity-centric view of interdependence"* to ecosystems and focuses on the configuration of activities that connect actors in an ecosystem to create and deliver value (Adner, 2017, p. 40). The structure of interdependence connects the actors in an ecosystem and determines the value proposition, as well as the types of actors and their positions within the ecosystem and in regard to the value proposition. (Adner, 2017; Ganco et al., 2020; Gomes et al., 2021; Hannah & Eisenhardt, 2018; Jacobides et al., 2018; Lütjen et al., 2019; Shipilov & Gawer, 2020). The core value proposition shapes the activities and interactions required for the ecosystem to function and acts as the ecosystem's boundary maker and connector of the actors (Adner, 2017).

The ecosystem-as-structure perspective comprises four key elements—activities, actors, positions, and links—which characterize the configuration of activities (Adner, 2017). Although the ecosystem-as-structure focuses on activities assumed by the co-creation of the value proposition, affiliation may also be incorporated as a component rendered by

the role-level interactions that rely on multilateral nongeneric complementarities (Hou & Shi, 2021; Jacobides et al., 2018). For the structural configuration of ecosystem activities, actor alignment is identified as a key challenge for ecosystem strategy compared to traditional business strategy, given the complexity of interorganizational relationships inherent in ecosystems (Adner, 2017). Unlike dyadic buyer–supplier interactions in supply chains, multiple and heterogeneous actors are required to co-create the ecosystem's value proposition, which adds to the complexity of interdependence among ecosystem actors (Adner & Kapoor, 2010; Jacobides et al., 2018; Shou et al., 2022).

Scholars have embraced the ecosystem-as-structure approach, recognizing its value in providing an actionable framework that calls for specific management approaches and strategies (Adner, 2017; Ganco et al., 2020; Hannah & Eisenhardt, 2018; Jacobides et al., 2018; Kapoor, 2018; Shipilov & Gawer, 2020). Furthermore, this approach illuminates how the structure of the ecosystem at the broader level can impact upstream and downstream actors in terms of innovation (Ganco et al., 2020; Zhang et al., 2022).

2.2.3. Ecosystem as Coevolution

The ecosystem-as-coevolution approach considers ecosystems as intricate forms of collaboration among diverse actors, emphasizing the significance of coevolution, adaptation, and interdependence among heterogeneous actors (Aarikka-Stenroos & Ritala, 2017; Adner, 2017; Gueler & Schneider, 2021; Moore, 1996, 2006; Ritala et al., 2020). This suggests that ecosystems are continually evolving and developing due to environmental changes and actor-level changes rendered by the complex interplay between cooperation and competition dimensions (Ansari et al., 2016; Hou & Shi, 2021; Mäkinen & Dedehayir, 2014; Moore, 1993; Snihur et al., 2018; Tiwana, 2015). The innovation ecosystem construct has gained research attention in crafting strategies in dynamic and coevolving ecosystems (Adner, 2006; Hou & Shi, 2021).

Coevolution, the salient dynamic characteristic of ecosystems (Shou et al., 2022), refers to reciprocal changes induced by interactions with the environment or other actors (Autio & Thomas, 2014; Basole, 2009; Daymond et al., 2022; Kauffman, 1993; Peltoniemi, 2006). In turn, coevolution regulates the interactions and dynamics of ecosystems (Thomas & Autio, 2019). This approach aligns with Moore's depiction of business ecosystems (2006) and the core ideas of evolutionary theory (Nelson & Winter, 1982). Moore (1996) recognized that, just like in biological ecosystems, firms coevolve to jointly improve their offerings and activities: *"Over time, they coevolve their capabilities and roles, and tend to align themselves with the direction set by one or more central companies. Those companies holding leadership roles may change over time"* (p. 26). Nonetheless, the roles of all ecosystem actors are not fixed and can adjust with changes in ecosystem dynamics (Hou & Shi, 2021; Iansiti & Levien, 2004a). This change in roles adds to ecosystem complexity and uncertainty (Hou & Shi, 2021; Thomas & Autio, 2019).

From this perspective, the ecosystem functions as a complex adaptive system that responds to external changes and seizes opportunities (Hou & Shi, 2021; Kauffman, 1993; Phillips & Ritala, 2019). Rooted in complexity theory (Capra, 2005), the change in the ecosystem environment and/or actors triggers further change and adaptation aimed at maintaining complementarity among ecosystem participants (Phillips & Ritala, 2019; Thomas & Autio, 2019; Volberda & Lewin, 2003). The coevolution view describes the competitive landscape of interdependent actors experiencing periods of change and stability in their complex collaborations (Bengtsson & Kock, 1999; Moore, 1993, 2006).

The coevolution view recognizes the ecological perspective of ecosystems, as the abundance and heterogeneity of ecosystem actors increase the ecosystem's complexity (P. J. Williamson & De Meyer, 2012). Additionally, the actors in the ecosystem bring their own objectives and intentions, which pose a source of potential conflict (ibid.). In this context, affiliation or alignment is critical for the focal firm in steering the coevolution process of the ecosystem (Adner, 2017; Hou & Shi, 2021). Moreover, the coevolution approach to ecosystems highlights that complementarities contribute to enabling coevolution in the relationships among ecosystem actors (Hou & Shi, 2021).

Overall, the ecosystem-as-coevolution perspective acknowledges the dynamic and complex nature of innovation ecosystems and highlights the need for firms to adopt both competitive and cooperative strategies to survive and thrive within the ecosystem. Several scholars have investigated various aspects of ecosystems from the coevolution perspective (Kwak et al., 2018), such as ecosystem strategy (Adner, 2006; Schroth & Häußermann, 2018), value creation (Adner & Kapoor, 2010) and ecosystem evolution (Daymond et al., 2022; Feng et al., 2019; Luo, 2018). However, further research on ecosystem dynamics and to what degree the ecosystem pursues stability or change is needed.

In the context of this thesis' topic, the ecosystem-as-coevolution perspective is particularly suitable, as complementors are often loosely connected, yet independent actors who play a crucial role in shaping the ecosystem. They rely on the focal firm to create demand for their complements. Therefore, understanding complementors as innovation ecosystem actors requires a coevolutionary perspective that considers the ecosystem as a dynamic and complex web of interactions and interdependencies among actors (Adner, 2017; Hou & Shi, 2021).

2.3. Complementors and Coevolutionary Logics

Complementors are actors who provide complementary products or services that customers may use together with the focal firm's proposition (Shipilov & Gawer, 2020). As coined by Brandenburger and Nalebuff (1996), complementors were defined as *"A player is your complementor if customers value your product more when they have the other player's product than when they have your product alone"* (p. 18). Complementors, along with suppliers, assemblers, and users, play direct value creation roles, showing complementors' active

participation and importance in contributing to co-creating the value proposition of the ecosystem (Dedehayir et al., 2018). Complementors are crucial to the success of the ecosystem and the viability of the focal firm due to the unlimited potential unlocked by their innovations (Adner, 2006; Dattée et al., 2018; Gawer, 2014; Inoue, 2021).

Complementors may be wrongfully perceived as consumers because of their downstream positions (Gawer, 2014). However, complementors are not buyers or suppliers in the ecosystem (Kapoor, 2013). Their advantage lies in their potential to increase the value pie (Brandenburger & Nalebuff, 1996). As complementors are autonomous actors and may originate from different industries, they engage in open innovation practices (Inoue, 2021; Radziwon & Bogers, 2019). Therefore, focal firms are encouraged to lock complementors in formal agreements (Jacobides et al., 2018) or to manage them through a dedicated business unit (Kapoor, 2013). Nevertheless, complementors often lack direct links or contractual arrangements with the focal firm (Inoue, 2021; Jacobides et al., 2018; Pidun et al., 2022). Adding their (potentially) different knowledge bases and interests, complementors may pose risks to the focal firm that impact the entire ecosystem. However, complementors can be influenced by focal firms because of their interdependence and loose coupling (Inoue, 2021; Wareham et al., 2014). Being loosely coupled refers to the varying degrees of impact a change may have and the various resulting mutations of the value proposition (Aldrich, 1979). Thus, like all ecosystem participants, complementors are expected to develop unique capabilities that would contribute to the realization of the full potential of the ecosystem's value proposition (Cenamor & Frishammar, 2021; Shou et al., 2022).

Collaboration is crucial in the complementors' interaction to realize the full potential of the ecosystem's value proposition (Cenamor & Frishammar, 2021; Shou et al., 2022). However, despite their collaborative nature, complementors may pose competitive tensions (Brandenburger & Nalebuff, 1996). Their relationships may be characterized by both cooperation for value creation and competition for value appropriation, shaping complementors' motivations to collaborate (Adner & Kapoor, 2010; Brandenburger & Nalebuff, 1996; Han et al., 2022; Kapoor, 2013; Yoffie & Kwak, 2006; Yoo et al., 2022). Complementors may thus pose varying challenges and competition threats. Established complementors may negatively impact the value of the ecosystem's proposition, becoming a competitor to the focal firm and developing a substitute (Adner & Lieberman, 2021). Complementors not only affect the incumbents in terms of profit, but they may also influence the ecosystem's evolution (ibid.).

Coevolutionary logics may explain the dynamics of complementors' relationships (Aarikka-Stenroos & Ritala, 2017; Kauffman, 1993; Volberda & Lewin, 2003). The dynamics in complementors' interactions and their implications for the co-creation of the focal offer link to their interdependence in an ecosystem (Adner & Kapoor, 2010; Cenamor, 2021; Hilbolling et al., 2020; Inoue, 2019; Wang & Miller, 2020). Interactions within an ecosystem are the essential element and rendition of coevolution (B. Liu et al., 2022; Moore, 1993; Rong et al., 2015; Song, 2016; Walrave et al., 2018). Changes and

adaptations in one actor, particularly the focal firm, lead to changes in other actors, such as complementors (Shou et al., 2022). Given that ecosystems constantly evolve and change (Nelson & Winter, 1982), developing and possessing unique capabilities is imperative for complementors. This complexity governed by coevolutionary logics increases with the coexistence of cooperation and competition in the interactions among heterogeneous actors, including complementors (Hannah & Eisenhardt, 2018; W. Hoffmann et al., 2018). This coevolution among ecosystem actors not only contributes to the dynamism and complexity of the ecosystem but also results in consolidating interdependent relationships among actors and efficiently delivering higher value for users (Shou et al., 2022; Tiwana, 2015; Wareham et al., 2014).

As elaborated in *2.2.3 Ecosystem as Coevolution*, ecosystem studies that take the coevolution perspective generally focus on the focal firms or the evolution of innovation ecosystems (Adner & Kapoor, 2016a; Daymond et al., 2022; Luo, 2018). However, the coevolution of other actors' relationships is neglected in innovation ecosystems (B. Liu et al., 2022). Thus, coevolutionary logics may develop our understanding of complementors' dynamics within an innovation ecosystem (Aarikka-Stenroos & Ritala, 2017).

3 Methodological Considerations

This section presents the methodological considerations regarding the framing and development of the thesis. The methodology adopted seeks to capture the complexity of complementors as innovation ecosystem actors by discussing the fundamental positions concerning the philosophy of science, followed by the research design, empirical context, data collection and analysis employed in the thesis. Although the methodology sections of each paper present in-depth details regarding the methodological decisions and actions of each study, this section converges the different elements to provide a comprehensive overview. Specifically, a first discussion of the research paradigm is followed by an overview of the research design and strategy. Next, the empirical context sets the overall scene for the empirical studies, with a subsequent presentation of the data collection and analysis approaches. Finally, the section concludes with a discussion of the ethical considerations and research limitations experienced.

3.1. Research Paradigm

This thesis adopted a pragmatic research approach to investigate the research questions and explore the complementors' dynamics, assumed capabilities, and challenges in an innovation ecosystem. Pragmatism is a research paradigm characterized by a focus on practicality, relevance, applicability, and the use of multiple methods to investigate complex phenomena (Creswell & Creswell, 2017; Kelemen & Rumens, 2008).

Pragmatism is a research paradigm that combines aspects of positivism and interpretivism, as it seeks to balance the objective measurement of data with an understanding of the subjective experiences and meanings that individuals attach to them (Creswell & Creswell, 2017). Pragmatist researchers do not dwell between objectivity and subjectivity (Biesta, 2010). Rather than metaphysical concepts, such as truth and reality, pragmatism focuses on solving practical problems in the real world while accepting the possibility of one or multiple realities being inquired empirically (Creswell & Plano Clark, 2011). From a pragmatist perspective, knowledge is seen as dynamic, time-bound, context-dependent, and socially constructed (D. L. Morgan, 2014; Silverman, 2019). According to pragmatist scholars, an objective reality exists independent of human experience, but it can only be accessed and known through human experience (D. L. Morgan, 2014). To grasp the complex and dynamic phenomenon of complementors' approaches to managing cooperation and competition in an innovation ecosystem, a pragmatic approach may allow the researcher to draw on multiple sources of data and methods to generate new theories and hypotheses that are useful for improving the ecosystem (Saunders et al., 2012). Relying on multiple methods and data sources ensured the validity and replicability of the studies. With the aim of developing useful insights into real-world challenges, the pragmatic approach assumes the adoption of a research design and strategy suited to the research questions. Therefore, pragmatist research is

more concerned with the relevancy of the research questions than adhering to certain methodological assumptions (Kelemen & Rumens, 2008; Silverman, 2019).

3.2. Research Strategy and Design

Case study. Considering the purpose of understanding complementors' participation and dynamics in an innovation ecosystem, soft systems methodology is deemed adequate (Phillips & Ritala, 2019). The research design used in this thesis relies on case studies adapted to various research philosophies and approaches, showing their flexibility and suitability for this research (Yin, 2018). Case studies are commonly employed in social science research due to their appropriateness in studying contemporary phenomena in real-life contexts (Eisenhardt, 1989; Eisenhardt & Graebner, 2007; Yin, 2018). To investigate the dynamic interactions among the actors involved in the case, such studies generally answer *how*, *what*, or *why* questions to understand facts, their causes, and their implications (Saunders et al., 2012; Yin, 2018). The rich insights unaffected by the researcher's influence have the potential to generate theoretical developments (Dubois & Gadde, 2002; Eisenhardt, 1989; Eisenhardt & Graebner, 2007). However, case studies have been criticized for the challenges they pose regarding the generalizability of the findings and the development of theories. In fact, through the logic of data analysis, case studies may generate generalizable findings for theoretical propositions and ensure compatibility with similar cases, compiling theory-building cases (Yin, 2018).

Abduction. In line with the pragmatism research paradigm, this thesis subscribes to abduction, as a type of inference that assumes generating explanations to account for observed phenomena, often in the absence of complete or conclusive evidence or information (Pierce, 1878). Abduction is a distinct approach that differs from deduction, which involves deriving specific conclusions from general assumptions, and induction, which implies generalizing specific observations to create a theory or hypothesis. Abductive research assumes an iterative process of integrating both theory and data in alternations between inductive and deductive approaches, leveraging their benefits (Dubois & Gadde, 2002; Saunders et al., 2012; Suddaby, 2006). With the purpose *"to discover new things* […] *rather than confirmation of existing theories"* (Dubois & Gadde, 2002, p. 559), abduction offers a flexible, non-linear process of refining initial patterns or themes by further gathering data and consulting the extant literature, leading to theoretical refinement (Dubois & Gadde, 2002, 2014; Saunders et al., 2012). Abduction allows for discovery, as it does not adhere to a single well-established theory (Dubois & Gadde, 2002). Considering its cyclical nature and inherent flexibility, abduction is well-suited to the complexity and context-specific nature of case study research, allowing for adaptation in approaches and hypotheses during investigation (ibid.).

Moreover, considering the complex nature of ecosystem dynamics governed by coevolution and coopetition, the case study approach with abductive reasoning is fitting to capture this phenomenon from the complementors' perspective. Abduction typically involves a process of starting with an incomplete understanding of a phenomenon,

allowing for iteration and flexibility during the research process (Dubois & Gadde, 2002). In practice, abduction allows us to start with the observation of complementors' interactions, capabilities, and challenges in the wind energy ecosystem and then generate possible explanations of the phenomenon. As this thesis uses exploratory studies without predetermined hypotheses or theories to test with heavy reliance on qualitative data from multiple and various sources of data, abductive reasoning is suitable. Using an abductive approach allows the papers in this dissertation to generate insights and develop a theoretical understanding of the studied phenomenon.

Research design of papers. The papers comprising the thesis include a review and three empirical articles. Paper I is a systematic review relying on a rigorous two-step analysis and motivated by understanding the concept of *complementors* and its development within the ecosystem literature stream.

Papers II and III consist of exploratory multiple case studies of eight Danish complementors in the WEE. The research design choice aligns with the individual purposes of the articles, i.e., mapping and investigating complementors' interaction dynamics and identifying the capabilities needed to cope with the inherent tensions of their interactions and participation in the WEE. Compared to a single case, investigating multiple cases increases the replicability and (external) validity of the findings by collecting in-depth data about various units and from different sources (Andriopoulos & Lewis, 2009; Eisenhardt & Graebner, 2007; Lingens et al., 2021; Yin, 2018). Furthermore, as our understanding of complementors as innovation ecosystem actors is limited and the research aims refer to processes or evolution over time, the exploratory approach is deemed suitable (Hannah & Eisenhardt, 2018).

Paper IV is a comparative study of two ports that act as complementors in the WEE. The selected ports are located in Denmark, a developed market and pioneer in wind energy, and China, an emerging powerhouse with great interest in this alternative renewable energy source (ETIPWind & WindEurope, 2021; Poulsen & Lema, 2017). Exploring two cases in a developed context versus an emerging context leads to pattern recognition and enables case comparison (Eisenhardt & Graebner, 2007).

Case selection. A critical step in performing a case study represents the case selection, as it may significantly affect the findings and their interpretation (Yin, 2018). The determinants involved in this decision vary from relevance to the purpose of the study and research questions, accessibility and richness of data, to degree of focus (Yin, 2018). The sampling strategy of this thesis is purposive sampling, with a focus on selecting cases that are relevant to the research questions, as well as the availability of data considering the limitations imposed by the COVID-19 pandemic. The cases illustrated in Table 3 and included in the empirical articles were selected first and foremost based on their ecosystem roles. Acting as complementors in the WEE represented the fundamental criterion for selection. Although more cases checked the relevance requirement during

the identification phase, accessibility to data limited the number to eight cases for Papers II and III, and two cases for Paper IV.

The former eight complementors headquartered in Denmark contribute to the WEE by providing various hardware, software, and services that are not compulsory components of wind turbines but enhance their value. Another selection condition included choosing only complementors that directly contribute to the value proposition of the WEE, preventing the dilution of the focal value proposition of the ecosystem (Adner & Kapoor, 2010). This delimitation ensured that the multiple case studies could grasp the phenomenon without the emergence of too many variables. Relying on multiple cases increases the reliability of replication and contribution to theoretical development (Eisenhardt & Graebner, 2007), while the diversity of cases, as illustrated in Table 3, reflects the heterogeneity of complementors in any given ecosystem. The complements the eight companies provide include lightning protection, blade add-ons, dehumidifiers, heating solutions and add-ons, transportation and retrofits, various digital solutions, monitoring and optimization software and services.

Paper IV examines ports as critical complementors of the offshore WEE, providing services and infrastructure for the installation, deployment, maintenance, and decommissioning of wind turbines (WindEurope, 2021). Although previously studied from a supply chain perspective in the same context (Poulsen & Hasager, 2017; Poulsen & Lema, 2017), investing ports as complementors to WEE benefits from understanding their downstream position after all the upstream components and complements have been brought together by the OEMs. Ports play a crucial complementary role to WEE, similar to how airport are vital to the Airbus A380 in Adner and Kapoor's illustration of complementors (Adner & Kapoor, 2010).

Empirical paper	Complementor pseudonym	Headquartered in	Case description
Papers II and III	A	Denmark	Dehumidifier provider
	B	Denmark	Retrofit solutions provider
	C	Denmark	Services and software provider
	D	Denmark	Lubrication tools and cartridges provider
	E	Denmark	Digital solutions and O&M provider
	F	Denmark	Heating solutions provider
	G	Denmark	Control solutions and service provider
	H	Denmark	Provider of blade add-ons, monitoring and optimization, services
Paper IV	Alpha	Denmark	Multihoming energy port
	Beta	China	Multihoming energy port

Table 3. Overview of the cases analyzed in the empirical papers.

3.3. Empirical Context

"The scariest dragons and the fiercest giants usually turn out to be no more than windmills."
(Don Quixote)

Standing in front of wind turbines that nowadays compete in size with the Eiffel Tower would probably even scare Don Quixote (Hogg, 2023). The empirical context of wind energy is a dynamic and rapidly evolving industry that has seen tremendous growth over the past few decades. Wind energy has become a major source of renewable energy worldwide, with installed capacity growing from 24 GW in 2001 to over 906 GW in 2022 (GWEC, 2023). Besides the component suppliers to turbines, the role of complementors in the wind energy ecosystem is critical, as they contribute to the innovation and growth of the industry. Complementors provide specialized expertise and innovation that can improve the performance and reliability of wind turbines, as well as reduce costs. They can also help to address the challenges faced by the wind energy industry, such as intermittency, grid integration, and environmental concerns.

Until recently, wind energy has been investigated as an innovation system by employing the supply chain perspective or the triple helix and its extensions (Bento & Fontes, 2015; Brink, 2017, 2019; Klagge et al., 2012; Poulsen & Hasager, 2017; Poulsen & Lema, 2017). This may be attributed to the undeniable implications of governmental bodies and universities in wind energy (Garud & Karnøe, 2003). Considering the influence of the institutional context, emphasizing the interactions and cooperation between government, industry, and academia is reasonable (Brink, 2017, 2019; Garud & Karnøe, 2003). However, industrialization, pipeline creation, a more stable supply chain, and modularity have led scholars to approach wind energy as an open innovation model that relies on interconnectedness between actors (Alam & Ansari, 2020; Brink, 2017; ETIPWind & WindEurope, 2021; Surie, 2017). In fact, wind energy in Denmark was found to be more responsive to cooperative relationships and interorganizational coordination (Garud & Karnøe, 2003). Thus, the wind energy ecosystem can be understood as an open system (Jacobides, 2019), more specifically an innovation ecosystem, because of multiple private, public, and societal actors, including heterogeneous complementors, collaborating to offer a common value proposition (Alam & Ansari, 2020; Y. Chen et al., 2014; Surie, 2017).

In this empirical context, the efficient delivery of aeolian energy comprises the core value proposition of the WEE (Aarikka-Stenroos & Ritala, 2017; Dattée et al., 2018; Ritala et al., 2013). Furthermore, various actors from different industry sectors are brought together, rendering their multihoming strategies. Blurred boundaries and multihoming strategy are characteristics of ecosystems (Adner, 2012, 2017, 2021). However, the cases studied in this thesis directly contribute to the value creation of aeolian energy, despite being active in other countries and ecosystems. Therefore, an innovation ecosystem approach seems timely and suitable to study the WEE and, more specifically,

complementors, actors that have not received a high degree of attention in the empirical context of wind energy.

It is expected that wind turbines will produce a higher energy yield, exhibit greater effectiveness, and maintain longer operational lifetimes. To achieve net-zero goals, wind energy must be scaled up based on the size of turbines and projects (Nylund et al., 2021). Despite the constant increase in recent decades, the size of turbines is still expected to double within the next decade, driven by the focal firms of the WEE, i.e., OEMs (Earls et al., 2021; ETIPWind & WindEurope, 2021). Currently, the world's largest rotor diameter is 252 meters for a 13.6 MW offshore turbine (R. Williamson, 2023). This exponential increase creates challenges in terms of manufacturing, transportation, installation, and operations for various ecosystem participants, including complementors (Hogg, 2023). To provide aeolian energy, various actors need to join forces for this purpose. This is a fundamental requirement for the development of any innovation ecosystem that aims to deliver a complex value proposition (Adner, 2017; Jacobides et al., 2018). Complements may accelerate the process of reaching net-zero carbon goals through efficient operations and increased lifetime of turbines. The benefits of complements in wind energy are various, e.g., increasing turbines' lifespan, reducing failures and potential power loss, and ensuring safety. For instance, ice detection, de-icing equipment, remote sensing, or robotic inspection can help protect the turbines installed in areas with extreme weather (ETIPWind & WindEurope, 2021).

The motivation to study the wind energy context is also driven by intensified interest in investing in and developing this ecosystem. With the objective to cease European consumption of Russian fossil fuels, Denmark, Germany, the Netherlands, and Belgium signed a cooperation agreement for a joint offshore wind project that aims at a capacity of 150 GW by 2050 (Buljan, 2022). Denmark, as a trailblazer in the realm of sustainable energy, has served as a source of inspiration for China. China's renewable energy infrastructure, particularly in the wind energy sector, was developed with the assistance and influence of Denmark (Poulsen & Hasager, 2017). Since then, China has become the world's largest wind energy market (CGTN, 2021; GWEC, 2023). Committed to achieving carbon neutrality by 2060, China's interest in wind energy will persist, but involving complementors to increase the performance and lifespan of turbines is crucial (CGTN, 2021). Studying wind energy complementors can thus provide insights into the dynamics of innovation ecosystems and inform policies and strategies for promoting the growth and sustainability of the wind energy industry.

3.4. Data Collection and Analysis

As surveys and models are considered strict in terms of conditions, such methods are restrictive and even unsuitable for studying dynamics and interactions (J. Chen et al., 2016; Yin, 2018). Thus, qualitative research methods are better suited to the purpose of this thesis. The units of study, which are the complementors, are not fully understood, making it challenging to isolate them from the complex context of the innovation

ecosystem. Therefore, this thesis includes multiple data collection processes for the four papers.

The main primary data collection technique for this thesis is interviews. To ensure consistency across the interviews and allow for flexibility to explore new topics and accommodate the conversation according to the information shared, semi-structured interview guides were developed for the empirical papers (Saunders et al., 2012). However, due to the spontaneity of the encounter, two interviews were unstructured, exploratory conversations about the topics of the study. The interview sample included complementors and other ecosystem actors, such as focal firms, component suppliers, university, industry organizations, and experts. The sample was mainly drawn from Denmark and, to a lesser degree, China to capture the diversity of complementors and their contributions to the innovation ecosystem of wind energy. The primary data consisted of 36 semi-structured interviews (of which two were unstructured) and 22 observations at various wind energy events, webinars, and seminars, held from April 2021 to March 2023, including a wind energy conference-exhibition. Participating in these events allowed for immersion in the WEE and the development of my understanding of its dynamics, value proposition, technology, and actors (Aldrich, 1979). Most interviews were conducted digitally between April 2021 and July 2022 due to COVID-19 travel restrictions. Thirty interviews were recorded and transcribed. Six interviewees refused to be recorded despite assuring them of confidentiality and anonymity. Nevertheless, extensive notes were taken during these interviews. The transcripts, memos, interview and observation notes, as well as the secondary data, were mainly coded in NVivo, a qualitative data analysis software. The interviews amounted to 2,093 minutes, with an average of 58.14 minutes, while the minimum and maximum were 30 and 90 minutes, respectively.

Secondary data were also collected and analyzed, comprising 474 reports, industry publications, academic articles, news, and webpages. The purpose of the secondary data was to complement and supplement the interview data, providing a broader perspective on complementors and a more nuanced understanding of the wind energy ecosystem at large. Relying on multiple sources of data allows for data triangulation, ensuring the reliability and validity of the findings (Creswell & Creswell, 2017; Saunders et al., 2012).

This thesis mainly relies on interview data and predominantly qualitative analyses. However, Paper II is an empirical study that uses a mixed-method approach, in addition to the review paper that performs bibliometric and content analyses on extant literature. The data analysis was predominantly qualitative for two empirical articles, i.e., Papers III and IV, while two papers followed a mixed-methods approach, i.e., Papers I and II (Creswell & Plano Clark, 2011). The qualitative data from the interviews, observations, and archival data were analyzed primarily through thematic analyses, with an emphasis on identifying patterns and themes that emerged from the data (Braun & Clarke, 2006; Creswell & Creswell, 2017). Cross-case analysis was also conducted to identify patterns and themes across the cases within the empirical papers. The process of first within-case

analysis, then cross-case analysis, employs replication logic to seek patterns across cases (Eisenhardt & Graebner, 2007). Table 4 provides an overview of the gathered data, applied methods, and techniques for analysis.

Paper I is a systematic review that employs a mixed-method approach to analyze the extant ecosystem literature. After conducting several rounds of searches using various keywords on Scopus and Web of Science, relevant ecosystem studies that (partially) deal with complementors were identified. The articles were screened and selected based on their relevance. The final dataset consisted of 253 articles that underwent the first quantitative analysis, followed by a qualitative analysis of the 44 most cited papers. A detailed search and selection process can be found under 4.3.1 Search Strategy and Data Selection.

Papers II and III selected eight cases of wind energy complementors headquartered in Denmark. The cases were chosen based on their relevance and data accessibility, considering the limitations imposed by the COVID-19 pandemic. Paper III is a purely qualitative study based on semi-structured interviews and secondary data with thematic analysis. While both papers followed a thematic analysis at the within-case and cross-case levels, Paper II also applied an initial topic modeling based solely on the 23 interviews with the Danish complementors, using the Latent Dirichlet Allocation (LDA) method. Topic modelling is an unsupervised machine learning method that can uncover latent topics and complex patterns in a corpus by analyzing the frequency and co-occurrence of words in a document (Antons et al., 2020; Blei, 2012; Blei et al., 2003; Lu & Chesbrough, 2021; Westerlund et al., 2018). Paper II used topic modeling to inform the second main analysis, i.e., qualitative analysis in NVivo, with purely inductive coding, resulting in a mixed-method design. As the reliability of the findings relying on topic modeling may be questioned, a main qualitative analysis was conducted to overcome this challenge. Five supplementary interviews with industry experts, observations from 13 wind energy-related events (e.g., webinars, conference, exhibition), and snapshots from social media posts of the complementors were included in the second analysis. Additionally, secondary data scraped from Google searches, news from Lexis Nevis, and manually gathered data about the complementors supplemented the primary data.

Paper IV is a comparative study of two ports based on 13 interviews, and observations and insights gathered at 15 webinars, seminars, and events related to (offshore) WEE. The challenge of conducting direct interviews with employees at the two ports, particularly the Chinese state-owned port (pseudonymized as Beta), determined the heavy collection of secondary data, which consisted of 316 articles, press releases, snapshots, ports' websites and related webpages, industry reports, conference presentations, videos, and recorded interviews. The analysis consisted of within- and cross-case thematic analysis.

Paper	Primary data	Secondary data	Method	Technique
Paper I	253 articles collected from Web of Science and Scopus 44 most relevant articles entered the content analysis		Mixed methods	Bibliometric analysis Content analysis
Paper II	23 semi-structured interviews with 8 complementors + 6 supplementary interviews with industry experts, component suppliers, and other actors (30 – 90 min; 58.14 min average; April 2021 – April 2022) Observations at 12 industry webinars and events, as well as 1 exhibition-conference	158 manually collected documents and web-scraped archival data from Google searches and LexisNexis	Mixed methods	Topic modeling Within- and cross-case thematic analysis inspired by systematic combining and flexible coding with results from topic modeling
Paper III	23 semi-structured interviews with 8 complementors (30 – 90 min; 59.65 min average; April-November 2021) Observations at 13 industry webinars and 1 conference-exhibition	articles, press releases, websites	Qualitative	Within and cross-case thematic analysis based on systematic combining and flexible coding
Paper IV	14 semi-structured and unstructured interviews (40 – 80 min; 57 min average; May 2021 – July 2022) Observations and insights gathered at 15 webinars, seminars, and events on offshore wind	316 articles, press releases, news, reports, snapshots, websites	Qualitative	Within- and cross-case thematic analysis

Table 4. Data, methods, and analyses of the papers.

3.5. Reliability and Validity of Findings

To ensure the quality and credibility of the findings, the reliability and validity of the research were taken into account. For this purpose, several measures were taken in this thesis.

The use of multiple sources of data, such as interviews with various actors, observations, and secondary data, provided a methodological triangulation of information to ensure the accuracy of the data (Jick, 1979; Patton, 2002). Using different data sources and employing different analysis methods with quantitative and quantitative analyses in Paper I and IV allowed for cross-validation of the findings. The interview guide and selection criteria of the data were also discussed with senior researchers to ensure the consistency of the data. As more than one researcher was involved in the interpretation and analysis of the papers, the thesis also employed investigator triangulation (Patton, 2002). Theory triangulation, which refers to using multiple theoretical constructs, concepts, or theories in the interpretation of empirical studies, was also employed in the research design (Patton, 2002). Relying on well-established concepts supported by abductive reasoning

and theoretical frameworks developed through systematic combining provided a sound basis for the research design. Additionally, the potential sources of bias, such as the researcher's own perspective on the data collected from interviewees, were mitigated by employing reflexivity and transparency in the research process, providing a clear and detailed account of the research design and analysis methods in each paper.

Validity refers to the accuracy and soundness of research results and the extent to which they reflect the real-world phenomena under investigation (Yin, 2018). In this thesis, several types of validity were considered, such as construct validity, internal validity, and external validity. To ensure construct validity, the theoretical constructs and measurement tools used in each paper were carefully selected and validated against existing research. This was necessary because the concepts of complementors and innovation ecosystems are complex and multifaceted. To contribute to construct validity, multiple sources of data were used, and triangulation was applied. Follow-up emails and conversations with respondents were also conducted to clarify various interview aspects.

Internal validity refers to the extent to which a study is able to establish causal relationships between independent and dependent variables. In the context of this research on complementors, internal validity was ensured through rigorous data collection and analysis procedures, such as triangulation, to minimize the influence of bias. Furthermore, peer debriefing was employed to seek feedback from senior researchers and experts in the field to validate the findings and interpretations.

External validity refers to the extent to which the findings of the studies can be generalized beyond the specific context of WEE in which the empirical studies were conducted. Complementors may vary across different industries and contexts, and to ensure the applicability of the findings, a wide range of complementors that provide different hardware, software, and service complements were examined. External validity was addressed by selecting a diverse set of case studies and by comparing and contrasting the findings with those of other relevant studies in the literature.

Reliability refers to the consistency and stability of the research results over time and across different situations (Yin, 2018). In this thesis, reliability was ensured through several measures, such as using established theoretical concepts, interview guide, and case study protocols. Multiple case studies were conducted, and rigorous data collections and analysis procedures were employed. Additionally, the use of a systematic literature review in Paper I helped ensure the reliability of the theoretical constructs used throughout the thesis. However, the qualitative nature of the research may limit the ability to replicate the studies with absolute precision.

In summary, several measures were used to enhance the reliability and validity of the research results, including the use of multiple sources of data, rigorous data collection and analysis procedures, and consideration of different types of validity and potential sources of bias. These efforts ensure the credibility and quality of the findings and

contribute to their generalizability and applicability to the real-world context of complementors in innovation ecosystems, providing a solid foundation for future research in this area.

3.6. Ethical Consideration and Research Limitations

Ethical considerations for this thesis involve obtaining informed consent from participants, maintaining confidentiality, and ensuring the privacy of participants by anonymizing their identity and the complementors' names, relying on the use of codes. Informed consent was obtained from all participants prior to the start of the interview and on the record. Pseudonyms and codes were allocated to interviewees and ecosystem actors, including the studied complementors. All data were kept confidential and anonymous, with only aggregated data reported.

The limitations of this thesis include the potential for bias in the selection of cases and participants. To address this limitation, a purposive sampling strategy was used to ensure that the selected cases and participants were relevant to the research question.

Another limitation is the potential for interviewer bias, which was addressed by using a semi-structured interview guide. However, the interviewees' answers reflect their own apprehension and perspective, which may not fully coincide with or be representative of the company they are employed in. Moreover, their shared stories relied on retrospection, which may have affected the interpretation of the events or facts. To tackle these limitations, the number of years of work experience of every interviewee in the WEE was checked on their LinkedIn profiles before the first contact. Furthermore, extensive secondary data were collected and analyzed in every empirical paper to strengthen the quality and reliability of the findings.

A third limitation originates from the scope of this research. Despite the complexity of the complementors' interactions, dynamics, and challenges, the focus is restricted to their participation in the WEE and solely on complementors with direct contributions to the core value proposition of the ecosystem. Thus, complementors' participation in other ecosystems and (the impact of) their multihoming strategies remain unexplored in the empirical papers.

Lastly, the generalizability of the findings may be of concern, given that the research embodied by this thesis considers a single empirical context, i.e., WEE, and two countries, Denmark and China. Nevertheless, the findings have implications for other contexts and settings. The abductive approach used in the three empirical papers recognizes the dynamic and complex nature of the innovation ecosystem and allows for an exploratory and in-depth investigation of complementors as ecosystem actors. While the studies were conducted in the wind energy context in Denmark and China, the findings may carry implications for other regions and contexts. For instance, Papers II and II conducted multiple case studies of Danish complementors in the wind energy

ecosystem, which increased the external validity of the findings and enabled a more nuanced understanding of complementors' interaction dynamics and capabilities needed to cope with the inherent tensions of their participation. In Paper IV, a comparative study of two ports in Denmark and China as complementors in the WEE led to pattern recognition and case comparison, providing insights into how complementors in developed and emerging contexts may experience similar complications in innovation ecosystem participation. While the adopted pragmatic approach emphasizes the practicality and applicability of knowledge, further research may develop and consolidate the generalizability of the findings to other contexts.

Part II

Papers

Part III

Conclusion

4 Discussion and Conclusion

The discussion section of this thesis provides an interpretation of the results obtained from the systematic review and empirical studies. The aim of this thesis was to investigate the interaction dimensions of cooperation and competition through the vantage point of complementors as innovation ecosystem actors. The key findings obtained from the empirical studies and the systematic review are summarized and contrasted with the existing literature in Section 8.1, and the theoretical and practical implications of the results are discussed in light of the research questions and objectives in Sections 8.2 and 8.3. Finally, some reflections on limitations and venues for future research are presented in Section 8.4.

4.1. Summary of the Findings and Discussion

The concept of complementors in ecosystems has gained increasing attention from the research stream, as they play a vital role in realizing the core value proposition, expanding the pie for all ecosystem actors, and determining the survival and development of the ecosystem. This discussion is based on four papers that provide insights into the interactions, capabilities, and challenges of complementors. By synthesizing the findings of the four papers, this thesis enhances our understanding of complementors as innovation ecosystem actors. First, it clarifies complementors' characteristics, roles, behaviors, and overlaps with intersecting concepts, i.e., complements, complementary assets, and complementarity. Second, it sheds light on the dynamics of complementors in the WEE by examining the cooperation and competition dimensions. Third, it identifies the capabilities that complementors need to manage the cooperation and competition dimensions in innovation ecosystems. Fourth, it provides insights into the approaches that complementors use to deal with complement challenges based on their complexity and willingness to comply. Table 21 provides an overview of the key findings of each paper.

Paper	Research question	Findings
Paper I	(1) What are complementors' characteristics and role(s) in ecosystems? (2) How do complementors behave in ecosystems? (3) How are the intersecting concepts understood in ecosystem literature?	(1) Characteristics: autonomous, adaptable, heterogeneous, rational, and entrepreneurial minded. Roles: value enhancer, legitimacy facilitator, ecosystem defender, ecosystem disruptor. (2) Heavily impacted by interdependence and coopetition forces, with various internal and external challenges and determinants to interact with various ecosystem actors. (3) Complementors strictly link with multilateral, non-generic complementarities. Complementary assets and complements can also refer to the offerings of other actors, e.g., focal firm.
Paper II	How do complementors' interactions evolve in an innovation ecosystem, and what are the drivers of change	Complementors' interactions are dynamic and complex, often developing a coopetitive nature, mainly due to external drivers of change. However, complementors' treatment of the interacting party is highly contingent on the latter's ecosystem position.

	that shift the dimension of these interactions?	
Paper III	What capabilities complementors, as innovation ecosystem actors, rely on to address the ecosystem challenges posed by their dynamic interactions?	Varying portfolios of adaptability, networking, balancing sharing and secrecy, ecosystem thinking, sensing, seizing, transforming, coopetition capability to cope with ecosystem evolution, ensure compatibility and meet focal firm's demands, maintain own position, and deal with coopetitive tensions.
Paper IV	How do complementors deal with complement challenges in an innovation ecosystem?	The choice of approach depends on the complexity of complement challenge and the complementor's willingness to comply, i.e., compliant collaboration, sub-ecosystem building, alignment pursuance, developing an ecosystem perspective, position leveraging.

Table 5. Summary of findings.

Paper I provides a comprehensive overview of complementors in business, platform, and innovation ecosystems by conducting a systematic literature review using bibliometric and content analyses. The review highlights complementors' roles, interactions, determinants, and challenges in realizing the core value proposition and determining the survival and development of the ecosystem. The study found that the concept of complementors has been stretched in multiple directions, causing a dilution of its perceived usefulness. Different types of ecosystems use different fundaments to define complementors, which may require an adjustment in their definition. The paper also identified complementors' autonomy as the most stated characteristic and as a reason for the complexity of their (coopetitive) relationships, affecting their responsiveness. Their autonomy is often associated with coordination challenges and risks for collaboration. Nevertheless, complementors have to follow certain rules or standards when participating in ecosystems. However, these restrictions and technological dependence may hinder complementors' autonomy. Complementors may be stimulated to innovate and develop in ecosystems that augment their autonomy. Furthermore, several roles of complementors in ecosystems have emerged, such as value enhancer, legitimacy facilitator, ecosystem disruptor, and ecosystem defender. The complementors' roles have been emphasized in business ecosystem studies, while platform ecosystem publications investigating complementors have become more numerous. This may be due to the agglomeration of complementors in platforms, their number, facile identification, or their absolute necessary presence on the platform for ecosystem success and dominance. Moreover, the review highlights interdependence and coopetition as dynamic forces of the complementors' relationships, as well as identifying the various determinants and challenges for engaging in interactions with focal firms and among complementors.

Paper II examines the interactions of complementors with other actors in the WEE, highlighting their complexity and dynamism. Furthermore, it reveals that complementors' interactions and treatment of the interacting party depend on the ecosystem position of the latter. The study identifies five types of interactions: interactions with focal firms, rival and peer complementors, intermediaries, and end-customers. Complementors' primary interactions are with focal firms, which initially tend to be cooperative but gradually become more complex and coopetitive. Complementors prefer to focus on cooperation and treat the focal firms as collaborators, despite the

present competition dimension in their interactions, primarily due to focal firms' entry into complementary market spaces. Complementors' interactions with rival complementors are based on competition in most cases examined, despite the possibilities of collaboration for co-innovation. Collegiality exists among complementors who do not perceive their rival complementors as direct competitors. With peer complementors and end-customers, the cooperation dimension dominates. Complementors also interact with intermediaries, such as agents, to access focal firms directly, and these interactions may develop a coopetitive nature.

Paper III uncovers the capabilities complementors possess to cope with several challenges rendered by their ecosystem participation and complex, dynamic interactions with heterogeneous actors. The paper identifies four categories of challenges: coping with ecosystem evolution and technological trends, ensuring compatibility and meeting the focal firm's requirements, maintaining their position and sustaining competitive advantage, and dealing with coopetitive tensions. The type of challenge that complementors must solve in their interactions determines a different portfolio of capabilities. Altogether, the study identifies eight capabilities: adaptability, networking, ecosystem thinking, balancing sharing and secrecy, sensing, seizing, coopetition capability, and transforming. Adaptability is an essential capability of complementors, allowing them to adjust according to changes in the innovation ecosystem and facilitating their ecosystem participation. As downstream providers of add-ons and services, complementors are highly responsive to the demands of focal firms, despite the restrictive information flow. Networking is another core capability that not only increases social capital but also facilitates balancing sharing and secrecy, ecosystem thinking, sensing, and seizing. Moreover, Paper III highlights that, despite their downstream position, complementors rely on ecosystem thinking to understand and act according to the interdependencies and complementarities generated in the innovation ecosystem. Additionally, the paper emphasizes that the identified capabilities are dynamic and interrelated, as they evolve, facilitate, or improve one another to deal with complex challenges that may arise in complementors' ecosystem interactions.

Paper IV investigates the complement challenges that innovation ecosystems face and how complementors deal with them. The interdependencies present in ecosystems lead to uncertainty, which intensifies when complement challenges occur. The paper identifies five coping approaches that two port-complementors, from developed and emerging economies, adopted in dealing with complement challenges in the offshore WEE: compliant collaboration, sub-ecosystem building, alignment pursuance, development of ecosystem perspective, and position leveraging. The first approach has a solely collaborative nature, where the ports continuously upgrade their infrastructure to accommodate the demands of the ecosystem. The following approaches break the boundaries of their complementary role and expand the ecosystem-level responsibilities of complementors. The sub-ecosystem building approach involves attracting ecosystem actors to build production facilities on the port premises, and it has several benefits, such as knowledge sharing, reduced transportation costs and time. Alignment pursuance

involves assembling actors into an aligned structure, a task that has been perceived as the focal firm's responsibility in the ecosystem literature. Developing an ecosystem perspective involves considering ecosystem dynamics and interdependence to identify and solve complement challenges. Finally, when complementors exhaust all viable options, they leverage their established position to influence and adjust the technological development of the ecosystem.

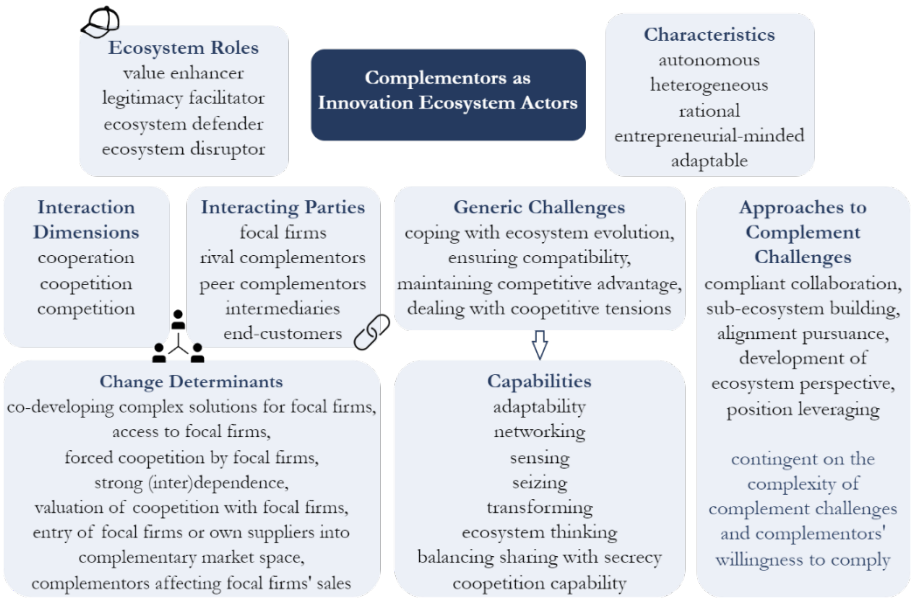

Figure 3. Overall framework across the four papers.

Overall, the findings reveal that complementors play a crucial role in unlocking greater potential for customers and expanding the pie for all ecosystem actors, enhancing value, and facilitating legitimacy. Complementors also contribute to determining the survival and development of the ecosystem, and their contribution to the core value of the ecosystem unlocks greater potential for the customers and expands the pie for all ecosystem actors. However, the unclear definition and its multiple conceptual fundaments may be the reason complementors are erroneously taken at face value. Complementors are generally seen as actors whose output enhances the value of a core product when consumed together. This statement is valid in platform ecosystems, where the user is typically the one who chooses complements. However, in innovation ecosystems, dual-party coordination may be required from the focal firm's and complementors' sides before the commercialization of the innovation and its complements. The importance of such coordination is illustrated in Paper IV, where lack of or improper coordination led to generating complement challenges that threaten the ecosystem through their potential to become bottlenecks.

Complementors' autonomy, a commonly stated characteristic, is often associated with coordination challenges and risks for collaboration. These may affect their responsiveness unless proper and targeted coordination is involved in their interactions with other ecosystem actors. However, autonomy is also the reason complementors are so adaptable to various external and internal changes happening in or due to the ecosystem in which they participate. Furthermore, being autonomous allows complementors to strategically think and act independently in order to deal with (complement) challenges.

The success of an ecosystem relies on effective interactions and coordination among heterogeneous actors (J. Chen et al., 2016). Complementors' interactions with ecosystem actors are often governed by coopetitive dynamics, except with end-customers. Complementors also engage in multihoming, a strategy that allows for risk diversification and value capture from other ecosystems.

The findings extend the coevolution perspective of innovation ecosystems through the complementors' perspective due to the focus on complementors' relationships and actions as governed by interdependence and coevolution over time. Tracking complementors and their activities over time contributes to the dynamic evolution of relational governance in the ecosystem (Gao et al., 2019; B. Liu et al., 2022; Ritala et al., 2013).

Furthermore, the capabilities required by complementors vary depending on the nature of the challenges they face. This finding highlights the need for dynamic perceptions of capabilities, which evolve and adjust with the ever-changing environment of the ecosystem (J. Chen et al., 2016). Through its coevolving nature, ecosystems are resilient and adaptable (Pidun et al., 2021, 2022). Adaptability is a key strength of successful ecosystems, requiring a modular setup featuring a stable core and interfaces, with highly variable components that can be easily added or subtracted.

Though focal firms and generally ecosystems tend to focus more on managing component challenges (Adner & Kapoor, 2010), complement challenges are imperative to be solved in order to achieve the ecosystem's core value proposition. The qualitative difference between the two types of challenges, which both may evolve into bottlenecks to value creation, stems from asymmetric interdependence and requires different approaches to be solved (Adner & Kapoor, 2010). Some approaches complementors rely on to solve complement challenges are beyond the usual scope of complementors' value-adding role (Carst & Hu, 2023; Cennamo & Santaló, 2019; Kapoor, 2013, 2018; Kapoor & Agarwal, 2017; P. J. Williamson & De Meyer, 2012). This means that complementors not only voice their concerns about complement challenges but also take proactive steps to address them, going beyond their usual responsibilities. Recognizing the actions of complementors in addressing these challenges is crucial for effectively aligning ecosystem resources to counter such threats.

The success of innovation ecosystems hinges on the willingness of autonomous parties to collaborate with each other, rather than relying on conventional buyer-supplier arrangements and formal contractual obligations (Pidun et al., 2022). Proper coordination is necessary to manage complementors' autonomy, coordination challenges, and risks for collaboration. However, despite their downstream position, complementors are not purely reactive actors; instead, they actively interact and strategize while being aware and considering the ecosystem's interdependencies and complementarities. Furthermore, due to their unique access to downstream information and knowledge flow, complementors deliver the second part of the ecosystem, completing the upstream side.

In conclusion, complementors are essential to the success of innovation ecosystems, and their strategic behaviors and performance require proper consideration and coordination to achieve (the full potential of) the ecosystem's core value proposition.

4.2. Theoretical Contributions

The findings of this research shed light on complementors as innovation ecosystem actors and contribute to the innovation ecosystem literature and the theoretical perspective of coevolutionary logics through complementors' lens. Though an integrative approach is recommended to fully capture the effects of an ecosystem (Hou & Shi, 2021), only focusing on the focal firm's perspective has provided only one side of the story. Thus, focusing on the downstream actors—more specifically, complementors—this thesis explored a complementary angle, a downstream perspective of ecosystems, its dynamics, and challenges. This thesis also further consolidates complementors and their crucial role in ecosystem theory, while delimitating their conceptual overlaps with complements, complementarity, and complementary assets. Better understanding of complementors may also improve the focal firm's collaboration and coordination with them.

Complementors were found to be autonomous actors. However, the extent of their autonomy can vary depending on the degree of their interdependence with the focal firm or the ecosystem. Nevertheless, complementors' autonomy can be both an advantage and a threat. Being autonomous allows complementors to adapt easily to various conditions rendered by the evolutionary nature of ecosystems or requirements from the focal firms. However, complementors' autonomy can also translate into coordination challenges for focal firms (Adner & Kapoor, 2010, 2016a; Brusoni & Prencipe, 2013; Kapoor, 2018).

Furthermore, the findings highlighted the complexity and common coopetitive nature of complementors' interactions in innovation ecosystems (Adner & Kapoor, 2016a; Basole, Russell, et al., 2015). Assuming that complementors would only engage in cooperation due to their primary value enhancement role is thus faulty. Aligning with coevolutionary logics, complementors' interactions are highly dynamic and ever-changing due to various drivers of change (Hou & Shi, 2021; B. Liu et al., 2022; Phillips & Ritala, 2019). This

thesis suggests that the coevolution perspective of ecosystems seems appropriate for capturing the dynamism and complexity of complementors' interactions embodied in an ecosystem. The complex patterns of cooperation and competition found in complementors' interactions, including in the extreme situation of dealing with complement challenges, are in line with complexity theory (J. P. Davis et al., 2009; Hannah & Eisenhardt, 2018). Contrary to the evolutionary view of actors being egocentric, focusing on their own short-term benefits, complementors were found to be capable of also developing a wider perspective of the environment and an understanding of interdependencies in ecosystem (Axelrod & Dion, 1988; Hannah & Eisenhardt, 2018). However, the extent of their ecosystem-level understanding remains unclear.

This thesis highlights that complementors are not mere downstream *"followers,"* challenging existing literature (Nambisan et al., 2018). Their broad ecosystem-level perspective extends beyond the narrow downstream focus and allows complementors to proactively engage with heterogeneous actors. Complementors also take the initiative in solving their complement challenges, rather than waiting for focal firms to identify and solve these challenges before developing into bottlenecks (Adner, 2017, 2021). Nevertheless, complementors seem to be aware of the limitations of their role(s) and influence in the ecosystem, as they consider that focal firms are the powerful actors that drive competition and create and impose governance rules (Adner, 2006, 2012, 2017; Adner & Kapoor, 2010; Huo et al., 2022; Wareham et al., 2014). Even so, coopetition is perceived as a natural phenomenon in the ecosystem by complementors, though not always desired or considered feasible (Bacon et al., 2020; Clarysse et al., 2014; Gnyawali & Madhavan, 2001). To cope with the challenges inherent in their complex and often coopetitive interactions and their ecosystem participation, complementors develop versatile capabilities, which are also dynamic in nature.

Moreover, while focal firms are generally responsible for ensuring the alignment structure in ecosystems (Adner & Kapoor, 2010; Blackburn et al., 2022; Huo et al., 2022; Walrave et al., 2018; P. J. Williamson & De Meyer, 2012), complementors can also take the initiative and attempt to mobilize diverse actors. In this way, complementors' ecosystem-level responsibilities expand beyond their complementary role. Furthermore, established complementors can leverage their position and implied power to influence the ecosystem's development, similar to bottleneck strategy (Hannah & Eisenhardt, 2018). Therefore, complementors can act beyond what is expected or requested by the ecosystem. For these reasons, it is essential not to underestimate the roles and impacts of complementors in ecosystems based solely on their cooperative value-adding nature. It is crucial to acknowledge that complementors can have a more substantial influence, complex interactions, and broader roles beyond their primary function.

4.3. Practical Implications

This thesis has practical implications for various actors in ecosystems, i.e., complementors and the ecosystem actors that interact with complementors, particularly focal firms.

Complementors need to be mindful of their core knowledge and critical design when engaging with OEMs and collaborating with other ecosystem actors to increase the complexity of their innovations. Complementors must carefully manage their interactions with focal firms due to the latter's purchasing power and ecosystem control. While complementors may prefer long-term cooperative goals, they need to be aware of the power imbalance between them and the focal firms. However, complementors' capabilities not only can help them deal with the inherent challenges of their interactions governed by cooperation and competition dynamics, but they are also crucial to the success of the ecosystem in which they participate. Moreover, not only focal firms, but also complementors, whether public or private, can benefit from ecosystem thinking, as it can lead to advancement of the ecosystem's development and strategy.

Intermediaries, such as agents, can help complementors by tapping into their well-established relationships with local OEMs. However, competition among agents and the multiple, yet similar, complements they provide add to the complexity of complementors' interactions with them.

Complementors, such as the ports in this thesis, can benefit from considering the entire value chain of the ecosystem's core value proposition and the strong relational synergies within the ecosystem under the threat of complement challenges. Implementing an ecosystem perspective is beneficial in identifying and solving complement challenges. Furthermore, multihoming, established complementors with strong interdependence can leverage their position to influence and adjust the technological development of the ecosystem when complementors exhaust all viable options.

For focal firms and other actors to effectively leverage complementors' resources and capabilities, they must navigate the complex network of complementors in the ecosystem. Complementors' perspective on interdependence and complexity, often governed by the coopetition dimension, allows for leveraging interaction dynamics and developing ecosystem strategies. Focal firms need to be aware of the impact of their entry into complementary markets on complementors' interactions and ecosystem participation. Actors, such as OEMs, policymakers, park developers, and turbine owners, need to understand how complementors interact and provide support to develop and maintain their capabilities to ensure timely complement development and delivery. Thus, managers need to develop capabilities that enable them to manage the cooperation and competition dimensions of their interactions in the ecosystem. Policymakers also need to create an institutional environment that supports collaboration and competition in the ecosystem, while addressing the challenges faced by complementors. Therefore, understanding

complementors' versatile capabilities can lead to more efficient collaborations and increased value enhancement for the ecosystem's core value proposition.

Finally, studying the wind energy empirical context as an innovation ecosystem represents a beneficial perspective capable of capturing and understanding interdependence and complexity. The ecosystem perspective also allows for leveraging interaction dynamics and developing ecosystem strategies (Alam & Ansari, 2020; Surie, 2017). Thus, wind energy stakeholders can use the innovation ecosystem perspective to improve complementor partnerships and enhance the overall performance of the WEE.

4.4. Limitations and Venues for Future Research

This section discusses the limitations and identifies potential avenues for future research on complementors in innovation ecosystems. This thesis is based on a single ecosystem, the WEE, which may limit the generalizability of the findings to other ecosystems. Future research can focus on other innovation ecosystems to prove their applicability. Moreover, future research could examine a larger and more diverse sample of complementors, their interactions, and capabilities in different innovation ecosystems (e.g., healthcare and fintech) to compare and explore the extent to which these findings are transferable.

This research exclusively studies complementors' interactions within a single ecosystem. However, cooperation and competition can also manifest across ecosystems. The intertwinement and influence between these two types of cooperation–competition dynamics could be further investigated. Moreover, how complementors' capabilities affect their coopetitive dynamics, performance, and competitive advantage in the ecosystem is worth of further exploration. In this regard, further data on complementors, longitudinal studies, and more insights from focal firms would solidify the findings and provide a holistic view of the ecosystem.

As most complementors in this thesis have other roles, i.e., component suppliers, and also multihome, it is important to determine the impact of these aspects on their interaction patterns and capabilities. Another venue for research is the role of institutional factors, such as regulations and policies, in shaping complementors' interactions with other actors in the ecosystem and their approaches to dealing with complement challenges.

Further evaluation of the consequences of the identified approaches on the complementors themselves, and from a broader perspective, on the entire ecosystem, are venues worth exploring longitudinally. In particular, studies may examine the impact and feasibility of the non-collaborative approach of position leveraging on the ecosystem, including its influence on other similar complementors.

Lastly, it is worth considering whether and how complementors' ownership and governance, either private or state-owned, affect their reactions in terms of interaction

and capabilities employed, as well as the selection of different coping approaches to complement challenges.

Overall, this thesis provides a foundation for future research on complementors in innovation ecosystems and highlights the importance of managing the cooperation and competition dimensions in these ecosystems.

References

Aarikka-Stenroos, L., & Ritala, P. (2017). Network management in the era of ecosystems: Systematic review and management framework. Industrial Marketing Management, 67(September), 23–36. https://doi.org/10.1016/j.indmarman.2017.08.010

Adner, R. (2006). Match your innovation strategy to your innovation ecosystem. Harvard Business Review, 84(4), 98+.

Adner, R. (2012). The wide lens: A new strategy for innovation. Penguin Group.

Adner, R. (2017). Ecosystem as Structure: An Actionable Construct for Strategy. Journal of Management, 43(1), 39–58. https://doi.org/10.1177/0149206316678451

Adner, R. (2021). Winning the Right Game: How to Disrupt, Defend, and Deliver in a Changing World. MIT Press.

Adner, R., & Feiler, D. (2019). Interdependence, perception, and investment choices: An experimental approach to decision making in innovation ecosystems. Organization Science, 30(1), 109–125. https://doi.org/10.1287/orsc.2018.1242

Adner, R., & Kapoor, R. (2010). Value creation in innovation ecosystems: How the structure of technological interdependence affects firm performance in new technology generations. Strategic Management Journal, 31(3), 306–333. https://doi.org/10.1002/smj.821

Adner, R., & Kapoor, R. (2016a). Innovation ecosystems and the pace of substitution: Re-examining technology S-curves. Strategic Management Journal, 37(4), 625–648. https://doi.org/10.1002/smj.2363

Adner, R., & Kapoor, R. (2016b). Right Tech, Wrong Time. Harvard Business Review, 94(11), 60+.

Adner, R., & Lieberman, M. (2021). Disruption Through Complements. Strategy Science, 1–19. https://doi.org/10.1287/stsc.2021.0125

Alaassar, A., Mention, A.-L., & Aas, T. H. (2021). Ecosystem dynamics: exploring the interplay within fintech entrepreneurial ecosystems. Small Business Economics, 0123456789. https://doi.org/10.1007/s11187-021-00505-5

Alaimo, C., Kallinikos, J., & Valderrama, E. (2020). Platforms as service ecosystems: Lessons from social media. Journal of Information Technology, 35(1), 25–48. https://doi.org/10.1177/0268396219881462

Alam, M. A., & Ansari, K. M. (2020). Open innovation ecosystems: toward low-cost wind energy startups. International Journal of Energy Sector Management, 14(5), 853–869. https://doi.org/10.1108/IJESM-07-2019-0010

Aldrich, H. (1979). Organizations and environments. Prentice-Hall, Inc.

Andriopoulos, C., & Lewis, M. W. (2009). Exploitation-exploration tensions and organizational ambidexterity: Managing paradoxes of innovation. Organization Science, 20(4), 696–717. https://doi.org/10.1287/orsc.1080.0406

Ansari, S. (Shaz), Garud, R., & Kumaraswamy, A. (2016). The Disruptor's Dilemma: TiVo and the U.S. Television Ecosystem. Strategic Management Journal, 37, 1829–1853. https://doi.org/10.1002/smj.2442

Argyres, N., Nickerson, J., & Ozalp, H. (2022). Platform competition and complementor responses: insights from combining design rules with the comparative adjustment, transaction, and opportunity cost framework. Industrial and Corporate Change. https://doi.org/10.1093/icc/dtac027

Autio, E. (2021). Orchestrating ecosystems: a multi-layered framework. Innovation: Organization and Management, 1–14. https://doi.org/10.1080/14479338.2021.1919120

Autio, E., Kenney, M., Mustar, P., Siegel, D., & Wright, M. (2014). Entrepreneurial innovation: The importance of context. Research Policy, 43(7), 1097–1108. https://doi.org/10.1016/J.RESPOL.2014.01.015

Autio, E., & Thomas, L. D. W. (2014). Innovation ecosystems: Implications for innovation management. Oxford Handbook of Innovation Management, January 2014, 204–228. https://doi.org/10.1093/oxfordhb/9780199694945.013.012

Awano, H., & Tsujimoto, M. (2022). Mechanisms for Business Ecosystem Members to Capture Value through the Strong Network Effect. Sustainability, 14(18), 11595. https://doi.org/10.3390/su141811595

Axelrod, R., & Dion, D. (1988). The Further Evolution of Cooperation. Science, 242(4884), 1385–1390.

Bacon, E., Williams, M. D., & Davies, G. (2020). Coopetition in innovation ecosystems: A comparative analysis of knowledge transfer configurations. Journal of Business Research, 115(November 2019), 307–316. https://doi.org/10.1016/j.jbusres.2019.11.005

Balka, K., Raasch, C., & Herstatt, C. (2014). The effect of selective openness on value creation in user innovation communities. Journal of Product Innovation Management, 31(2), 392–407. https://doi.org/10.1111/jpim.12102

Basole, R. C. (2009). Structural Analysis and Visualization of Ecosystems: A Study of Mobile Device Platforms. AMCIS 2009 Proceedings, 1–11. http://aisel.aisnet.org/amcis2009/292

Basole, R. C., Park, H., & Barnett, B. C. (2015). Coopetition and convergence in the ICT ecosystem. Telecommunications Policy, 39(7), 537–552. https://doi.org/10.1016/j.telpol.2014.04.003

Basole, R. C., Russell, M. G., Huhtamäki, J., Rubens, N., Still, K., & Park, H. (2015). Understanding business ecosystem dynamics: A data-driven approach. ACM Transactions on Management Information Systems, 6(2). https://doi.org/10.1145/2724730

Bengtsson, M., & Kock, S. (1999). Cooperation and competition in relationships between competitors in business networks. Journal of Business & Industrial Marketing, 14(3), 178–194. https://doi.org/10.1108/08858629910272184

Bengtsson, M., & Kock, S. (2000). "Coopetition" in Business Networks — to Cooperate and Compete Simultaneously. Industrial Marketing Management, 29(5), 411–426.

Bengtsson, M., & Kock, S. (2014). Coopetition - Quo Vadis? Past Accomplishments and Future Challenges. Industrial Marketing Management, 43, 180–188.

Bengtsson, M., Raza-Ullah, T., & Vanyushyn, V. (2016). The coopetition paradox and tension: The moderating role of coopetition capability. Industrial Marketing Management, 53, 19–30. https://doi.org/10.1016/j.indmarman.2015.11.008

Bento, N., & Fontes, M. (2015). The construction of a new technological innovation system in a follower country: Wind energy in Portugal. Technological Forecasting and Social Change, 99, 197–210. https://doi.org/10.1016/J.TECHFORE.2015.06.037

Biesta, G. (2010). Pragmatism and the philosophical foundations of mixed methods research. In A. Tashakkori & C. Teddlie (Eds.), Handbook of Mixed Methods in Social and Behavioral Research (2nd ed., pp. 95–117). Sage.

Blackburn, O., Ritala, P., & Keränen, J. (2022). Digital Platforms for the Circular Economy: Exploring Meta-Organizational Orchestration Mechanisms. Organization & Environment, 108602662211307. https://doi.org/10.1177/10860266221130717

Bogers, M., Sims, J., & West, J. (2019). What Is an Ecosystem? Incorporating 25 Years of Ecosystem Research. 2019 Meeting of the Academy of Management Proceedings, 1–29. https://doi.org/10.5465/ambpp.2019.11080abstract

Bogers, M., & West, J. (2012). Managing Distributed Innovation: Strategic Utilization of Open and User Innovation. Creativity and Innovation Management, 21(1), 61–75. https://doi.org/10.1111/J.1467-8691.2011.00622.X

Boudreau, K. J. (2010). Open platform strategies and innovation: Granting access vs. devolving control. Management Science, 56(10), 1849–1872. https://doi.org/10.1287/mnsc.1100.1215

Boudreau, K. J. (2012). Let a thousand flowers bloom? An early look at large numbers of software app developers and patterns of innovation. Organization Science, 23(5), 1409–1427. https://doi.org/10.1287/orsc.1110.0678

Boudreau, K. J., & Jeppesen, L. B. (2015). Unpaid Crowd Complementors: The Platform Network Effect Mirage. Strategic Management Journal, 36, 1761–1777. https://doi.org/10.1002/smj.2324

Bouncken, R. B., & Kraus, S. (2013). Innovation in knowledge-intensive industries: The double-edged sword of coopetition. Journal of Business Research, 66(10), 2060–2070. https://doi.org/10.1016/j.jbusres.2013.02.032

Boyer, J. (2020). Toward an evolutionary and sustainability perspective of the innovation ecosystem: Revisiting the Panarchy model. Sustainability (Switzerland), 12(8), 1–17. https://doi.org/10.3390/SU12083232

Brandenburger, A. M., & Nalebuff, B. J. (1996). Co-opetition: 1. A revolutionary mindset that combines competition and cooperation. 2. The Game Theory strategy that's changing the game of business. Currency Doubleday.

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. Qualitative Research in Psychology, 3(2), 77–101. https://doi.org/10.1191/1478088706qp063oa

Brink, T. (2017). Organising for innovation in regional innovation systems: from fragmented innovation ecosystems to the joint aim for competitiveness of offshore wind energy. Triple Helix, 4(1), 1. https://doi.org/10.1186/s40604-017-0044-2

Brink, T. (2019). The Triple Helix Frame Contributes to Strategic Innovation in Nearshore Wind Park Ecosystems. Triple Helix, 6(1), 1–35. http://search.ebscohost.com/login.aspx?direct=true&db=buh&AN=142282087&site=ehost-live

Brusoni, S., & Prencipe, A. (2013). The organization of innovation in ecosystems: Problem framing, problem solving, and patterns of coupling. Advances in Strategic Management, 30, 167–194. https://doi.org/10.1108/S0742-3322(2013)0000030009

Buljan, A. (2022). Four EU Countries Set Joint Target of 150 GW of Offshore Wind by 2050. OffshoreWIND.Biz. https://www.offshorewind.biz/2022/05/18/four-eu-countries-set-joint-target-of-150-gw-of-offshore-wind-by-2050/

Burström, T., Lahti, T., Parida, V., Wartiovaara, M., & Wincent, J. (2023). A definition, review, and extension of global ecosystems theory: Trends, architecture and orchestration of global VCs and mechanisms behind unicorns. Journal of Business Research, 157. https://doi.org/10.1016/j.jbusres.2022.113605

Capra, F. (2005). Complexity and life. Theory, Culture and Society, 22(5), 33–44. https://doi.org/10.1177/0263276405057046

Carst, A. E., & Hu, Y. (2023). Complementors as Ecosystem Actors: A Systematic Review. [Unpublished].

Cenamor, J. (2021). Complementor competitive advantage: A framework for strategic decisions. Journal of Business Research, 122(September 2020), 335–343. https://doi.org/10.1016/j.jbusres.2020.09.016

Cenamor, J., & Frishammar, J. (2021). Openness in platform ecosystems: Innovation strategies for complementary products. Research Policy, 50(1). https://doi.org/10.1016/j.respol.2020.104148

Cennamo, C., Ozalp, H., & Kretschmer, T. (2018). Platform Architecture and Quality Trade-offs of Multihoming Complements. Information Systems Research, 29(2), 461–478.

Cennamo, C., & Santaló, J. (2019). Generativity tension and value creation in platform ecosystems. Organization Science, 30(3), 617–641. https://doi.org/10.1287/orsc.2018.1270

CGTN. (2021, September 13). China's efforts in offshore wind power crucial for carbon neutrality. The State Council of the People's Republic of China. http://english.www.gov.cn/policies/policywatch/202109/13/content_WS613f55ddc6d0df57f98e01ff.html

Chandler, J. D., Danatzis, I., Wernicke, C., Akaka, M. A., & Reynolds, D. (2019). How Does Innovation Emerge in a Service Ecosystem? Journal of Service Research, 22(1), 75–89. https://doi.org/10.1177/1094670518797479

Chen, J., Liu, X., & Hu, Y. (2016). Establishing a CoPs-based innovation ecosystem to enhance competence - the case of CGN in China. International Journal of Technology Management, 72(1/2/3), 144–170. https://doi.org/10.1504/IJTM.2016.080549

Chen, Y., Rong, K., Xue, L., & Luo, L. (2014). Evolution of collaborative innovation network in China's wind turbine manufacturing industry. International Journal of Technology Management, 65(1/2/3/4), 262–299.

Chesbrough, H. (2003). Open innovation: The new imperative for creating and profiting from technology. Harvard Business Press.

Clarysse, B., Wright, M., Bruneel, J., & Mahajan, A. (2014). Creating value in ecosystems: Crossing the chasm between knowledge and business ecosystems. Research Policy, 43(7), 1164–1176. https://doi.org/10.1016/j.respol.2014.04.014

Clements, M. T., & Ohashi, H. (2005). Indirect Network Effects and the Product Cycle: Video Games in the U.S., 1994-2002. The Journal of Industrial Economics, LIII(4), 515–543.

Cobben, D., Ooms, W., Roijakkers, N., & Radziwon, A. (2022). Ecosystem types: A systematic review on boundaries and goals. Journal of Business Research, 142, 138–164. https://doi.org/10.1016/j.jbusres.2021.12.046

Creswell, J. W., & Creswell, J. D. (2017). Research design: Qualitative, quantitative, and mixed methods approaches. Sage publications.

Creswell, J. W., & Plano Clark, V. L. (2011). Designing and Conducting Mixed Methods Research (2nd ed.). Sage.

Cusumano, M. A., & Gawer, A. (2002). The Elements of Platform Leadership. MIT Sloan Management Review, 51–58. https://doi.org/10.1016/S0041-5553(89)80021-7

Dattée, B., Alexy, O., & Autio, E. (2018). Maneuvering in poor visibility: How firms play the ecosystem game when uncertainty is high. Academy of Management Journal, 61(2), 466–498. https://doi.org/10.5465/amj.2015.0869

Davis, J. P., Eisenhardt, K. M., & Bingham, C. B. (2009). Optimal Structure, Market Dynamism, and the Strategy of Simple Rules. Administrative Science Quarterly, 54, 413–452.

Daymond, J., Knight, E., Rumyantseva, M., & Maguire, S. (2022). Managing ecosystem emergence and evolution: Strategies for ecosystem architects. Strategic Management Journal. https://doi.org/10.1002/smj.3449

Dedehayir, O., Mäkinen, S. J., & Ortt, J. R. (2022). Innovation ecosystems as structures: Actor roles, timing of their entrance, and interactions. Technological Forecasting and Social Change, 183, 121875. https://doi.org/10.1016/j.techfore.2022.121875

Dedehayir, O., Makinen, S. J., Ortt, J. R., Mäkinen, S. J., & Ortt, J. R. (2018). Roles during innovation ecosystem genesis: A literature review. Technological Forecasting and Social Change, 136, 18–29. https://doi.org/10.1016/j.techfore.2016.11.028

Deilen, M., & Wiesche, M. (2021). The Role of Complementors in Platform Ecosystems. In F. Ahlemann, R. Schütte, & S. Stieglitz (Eds.), Innovation Through Information Systems. WI 2021. Lecture Notes in Information Systems and Organisation (Vol. 48, pp. 473–488). Springer. https://doi.org/10.1007/978-3-030-86800-0_33

Dorn, S., & Albers, S. (2018). A Multi-Level Perspective on Managing Coopetition. In A.-S. Fernandez, P. Chiambaretto, F. Le Roy, & W. Czakon (Eds.), The Routledge Companion to Coopetition Strategies (pp. 205–212). Routledge.

Dubois, A., & Gadde, L. E. (2002). Systematic combining: An abductive approach to case research. Journal of Business Research, 55(7), 553–560. https://doi.org/10.1016/S0148-2963(00)00195-8

Dubois, A., & Gadde, L.-E. (2014). "Systematic combining"—A decade later. Journal of Business Research, 67(6), 1277–1284. https://doi.org/10.1016/j.jbusres.2013.03.036

Earls, E., Zhao, F., & Laird, D. (2021). Size matters. World Wind Technology, 28–30. https://content.yudu.com/web/442ay/0A4485h/WWT023-Pros/html/index.html

Eckhardt, J. T., Ciuchta, M. P., & Carpenter, M. (2018). Open innovation, information, and entrepreneurship within platform ecosystems. Strategic Entrepreneurship Journal, 12(3), 369–391. https://doi.org/10.1002/sej.1298

Eisenhardt, K. M. (1989). Building Theories from Case Study Research. Academy of Management Review, 14(4), 532–550. https://doi.org/10.5465/amr.1989.4308385

Eisenhardt, K. M., & Graebner, M. E. (2007). Theory Building from Cases: Opportunities and Challenges. Academy of Management Journal, 50(1), 25–32.

Ethiraj, S. K. (2007). Allocation of inventive effort in complex product systems. Strategic Management Journal, 28(6), 563–584. https://doi.org/10.1002/smj.622

ETIPWind, & WindEurope. (2021). Getting fit for 55 and set for 2050. https://etipwind.eu/publications/getting-fit-for-55/

Facin, A. L. F., De Vasconcelos Gomes, L. A., De Mesquita Spinola, M., & Salerno, M. S. (2016). The Evolution of the Platform Concept: A Systematic Review. IEEE Transactions on Engineering Management, 63(4), 475–488. https://doi.org/10.1109/TEM.2016.2593604

Fasnacht, D. (2018). Open Innovation Ecosystems: Creating New Value Constellations in the Financial Services (2nd ed.). Springer International Publishing AG. https://doi.org/10.1007/978-3-319-76394-1_2

Feng, N., Fu, C., Wei, F., Peng, Z., Zhang, Q., & Zhang, K. H. (2019). The key role of dynamic capabilities in the evolutionary process for a startup to develop into an innovation ecosystem leader: An indepth case study. Journal of Engineering and Technology Management, 54(193), 81–96. https://doi.org/10.1016/j.jengtecman.2019.11.002

Ferasso, M., Wunsch Takahashi, A. R., & Prado Gimenez, F. A. (2018). Innovation ecosystems: a meta-synthesis. International Journal of Innovation Science, 10(4), 495–518. https://doi.org/10.1108/IJIS-07-2017-0059

Fernandez, A.-S., Chiambaretto, P., & Czakon, W. (2018). Coopetition: From Neologism to a New Paradigm. In A.-S. Fernandez, P. Chiambaretto, F. Le Roy, & W. Czakon (Eds.), The Routledge Companion to Coopetition Strategies (pp. 1–10). Routledge.

Foguesatto, C. R., Santini, M. A. F., Martins, B. V., Faccin, K., De Mello, S. F., & Balestrin, A. (2021). What is Going on Recently in the Innovation Ecosystem Field? A Bibliometric and Content-Based Analysis. International Journal of Innovation Management, 25(07). https://doi.org/10.1142/S1363919621300014

Fransman, M. (2014). Models of Innovation in Global ICT Firms: The Emerging Global Innovation Ecosystems.

Fuller, J., Jacobides, M. G., & Reeves, M. (2019). The Myths and Realities of Business Ecosystems. MIT Sloan Management Review, 60(3), 1–9. https://mitsmr.com/2Nt8fmC

Ganco, M., Kapoor, R., & Lee, G. K. (2020). From Rugged Landscapes to Rugged Ecosystems: Structure of Interdependencies and Firms' Innovative Search. Academy of Management Review, 45(3), 646–674. https://doi.org/10.5465/amr.2017.0549%0AFROM

Gao, Y., Liu, X., & Ma, X. (2019). How do firms meet the challenge of technological change by redesigning innovation ecosystem? A case study of IBM. International Journal of Technology Management, 80(3–4), 241–265. https://doi.org/10.1504/IJTM.2019.100285

Garud, R., & Karnøe, P. (2003). Bricolage versus breakthrough: distributed and embedded agency in technology entrepreneurship. Research Policy, 32, 277–300.

Gawer, A. (2014). Bridging differing perspectives on technological platforms: Toward an integrative framework. Research Policy, 43(7), 1239–1249. https://doi.org/10.1016/j.respol.2014.03.006
Gawer, A., & Cusumano, M. A. (2002). Platform Leadership: How Intel, Microsoft, and Cisco Drive Industry Innovation. Harvard Business School Press.
Gawer, A., & Cusumano, M. A. (2014). Industry platforms and ecosystem innovation. Journal of Product Innovation Management, 31(3), 417–433. https://doi.org/10.1111/jpim.12105
Gnyawali, D. R., & Madhavan, R. (2001). Cooperative Networks and Competitive Dynamics: A Structural Embeddedness Perspective. The Academy of Management Review, 26(3), 431. https://doi.org/10.2307/259186
Gnyawali, D. R., Madhavan, R., He, J., & Bengtsson, M. (2016). The competition-cooperation paradox in inter-firm relationships: A conceptual framework. Industrial Marketing Management, 53, 7–18. https://doi.org/10.1016/j.indmarman.2015.11.014
Gnyawali, D. R., & Park, B. R. (2009). Co-opetition and Technological Innovation in Small and Medium-Sized Enterprises: A Multilevel Conceptual Model. Journal of Small Business Management, 47(3), 308–330.
Gobble, M. M. (2014). Charting the Innovation Ecosystem. Research-Technology Management, 57(4), 55–59. https://doi.org/10.5437/08956308X5704005
Gomes, L. A. de V., dos Santos, M. G., & Facin, A. L. F. (2022). Uncertainty management in global innovation ecosystems. Technological Forecasting and Social Change, 182(December 2020), 121787. https://doi.org/10.1016/j.techfore.2022.121787
Gomes, L. A. de V., Facin, A. L. F., Salerno, M. S., & Ikenami, R. K. (2018). Unpacking the innovation ecosystem construct: Evolution, gaps and trends. Technological Forecasting and Social Change, 136, 30–48. https://doi.org/10.1016/j.techfore.2016.11.009
Gomes, L. A. de V., Flechas, X. A., Facin, A. L. F., & Borini, F. M. (2021). Ecosystem management: Past achievements and future promises. Technological Forecasting and Social Change, 171(June), 120950. https://doi.org/10.1016/j.techfore.2021.120950
Granstrand, O., & Holgersson, M. (2020). Innovation ecosystems: A conceptual review and a new definition. Technovation, 90–91(June 2018), 102098. https://doi.org/10.1016/j.technovation.2019.102098
Gueler, M. S., & Schneider, S. (2021). The resource-based view in business ecosystems: A perspective on the determinants of a valuable resource and capability. Journal of Business Research, 133, 158–169. https://doi.org/10.1016/j.jbusres.2021.04.061
GWEC. (2023). Global Wind Report 2023. https://gwec.net/wp-content/uploads/2023/03/GWR-2023_interactive.pdf
Han, J., Zhou, H., Lowik, S., & de Weerd-Nederhof, P. (2022). Enhancing the understanding of ecosystems under innovation management context: Aggregating conceptual boundaries of ecosystems. Industrial Marketing Management, 106, 112–138. https://doi.org/10.1016/j.indmarman.2022.08.008
Hannah, D. P., & Eisenhardt, K. M. (2018). How firms navigate cooperation and competition in nascent ecosystems. Strategic Management Journal, 39(12), 3163–3192. https://doi.org/10.1002/smj.2750
Hermalin, B. E., & Katz, M. L. (2011). Customer or Complementor? Intercarrier Compensation with Two-Sided Benefits. Journal of Economics and Management Strategy, 20(2), 379–408. https://doi.org/10.1111/j.1530-9134.2011.00292.x
Hilbolling, S., Berends, H., Deken, F., & Tuertscher, P. (2020). Complementors as connectors: managing open innovation around digital product platforms. R&D Management, 50(1), 18–30. https://doi.org/10.1111/radm.12371
Hoffmann, M. G., Murad, E. P., Da Cunha Lemos, D., Farias, J. S., & Sanches, B. L. (2022). Characteristics Of Innovation Ecosystems' Governance: An Integrative Literature Review. International Journal of Innovation Management. https://doi.org/10.1142/S1363919622500621
Hoffmann, W., Lavie, D., Reuer, J. J., & Shipilov, A. (2018). The interplay of competition and cooperation. Strategic Management Journal, 39, 3033–3052. https://doi.org/10.1002/smj.2965
Hogg, S. (2023, March 1). Wind Turbines Are Already Skyscraper-Sized Is There Any Limit To How Big They Will Get? MENAFN. https://menafn.com/1105376899/Wind-Turbines-Are-Already-Skyscraper-Sized-Is-There-Any-Limit-To-How-Big-They-Will-Get
Holgersson, M., Granstrand, O., & Bogers, M. (2018). The evolution of intellectual property strategy in innovation ecosystems: Uncovering complementary and substitute appropriability regimes. Long Range Planning, 51(2), 303–319. https://doi.org/10.1016/j.lrp.2017.08.007
Hou, H., & Shi, Y. (2021). Ecosystem-as-structure and ecosystem-as-coevolution: A constructive examination. Technovation, 100, 102193. https://doi.org/10.1016/j.technovation.2020.102193
Huang, H., Chen, J., Yu, F., & Zhu, Z. (2019). Establishing the Enterprises' Innovation Ecosystem Based on Dynamics Core Competence—The Case of China's High-Speed Railway. Emerging Markets Finance and Trade, 55(4), 843–862. https://doi.org/10.1080/1540496X.2018.1518216

Huo, L., Shao, Y., Wang, S., & Yan, W. (2022). Identifying the role of alignment in developing innovation ecosystem: value co-creation between the focal firm and supplier. Management Decision, 60(7), 2092–2125. https://doi.org/10.1108/MD-03-2021-0433

Iansiti, M., & Levien, R. (2004a). Strategy as Ecology. Harvard Business Review, 82(3), 68–78.

Iansiti, M., & Levien, R. (2004b). The keystone advantage: What the new dynamics of business ecosystems mean for strategy, innovation, and sustainability. Harvard Business Press.

Inoue, Y. (2019). Winner-takes-all or co-evolution among platform ecosystems: A look at the competitive and symbiotic actions of complementors. Sustainability, 11(726), 1–25. https://doi.org/10.3390/su11030726

Inoue, Y. (2021). Indirect innovation management by platform ecosystem governance and positioning: Toward collective ambidexterity in the ecosystems. Technological Forecasting and Social Change, 166, 120652. https://doi.org/10.1016/j.techfore.2021.120652

Iyer, B. R., & Henderson, J. C. (2012). Business value from clouds: Learning from users. MIS Quarterly Executive, 11(1), 52–60. https://www.scopus.com/inward/record.uri?eid=2-s2.0-84864960811&partnerID=40&md5=48fc7571cc3b2077e2e903254b71c126

Jackson, D. J. (2011). What is an Innovation Ecosystem? National Science Foundation, 1(2), 1–13. http://www.sustainablescale.org/ConceptualFramework/UnderstandingScale/BasicConcepts/EcosystemFunctionsS

Jacobides, M. G. (2019). In the ecosystem economy, what's your strategy? Harvard Business Review, September-October, 128–138.

Jacobides, M. G., Cennamo, C., & Gawer, A. (2018). Towards a theory of ecosystems. Strategic Management Journal, 39(8), 2255–2276. https://doi.org/10.1002/smj.2904

Jick, T. D. (1979). Mixing Qualitative and Quantitative Methods: Triangulation in Action. Administrative Science Quarterly, 24(4), 602–611.

Kang, J.-S., Lee, H.-Y., & Tsai, J. (2011). An analysis of interdependencies in mobile communications technology: The case of WiMAX and the development of a market assessment model. Technology in Society, 33(3–4), 284–293. https://doi.org/10.1016/j.techsoc.2011.10.002

Kapoor, R. (2013). Collaborating with complementors: What do firms do? Advances in Strategic Management, 30, 3–25. https://doi.org/10.1108/S0742-3322(2013)0000030004

Kapoor, R. (2018). Ecosystems: broadening the locus of value creation. Journal of Organization Design, 7(12), 1–16. https://doi.org/10.1186/s41469-018-0035-4

Kapoor, R., & Agarwal, S. (2017). Sustaining superior performance in business ecosystems: Evidence from application software developers in the iOS and Android smartphone ecosystems. Organization Science, 28(3), 531–551. https://doi.org/10.1287/orsc.2017.1122

Kapoor, R., & Lee, J. M. (2013). Coordinating and competing in ecosystems: How organizational forms shape new technology investments. Strategic Management Journal, 34(3), 274–296. https://doi.org/10.1002/smj.2010

Kauffman, S. A. (1993). The Origins of Orders: Self-Organization and Selection in Evolution. Oxford University Press.

Kelemen, M. L., & Rumens, N. (2008). Organisational Paradigms and Management Research. In An Introduction to Critical Management Research (pp. 21–38). SAGE Publications, Ltd.

Khademi, B. (2020). Ecosystem Value Creation and Capture: A Systematic Review of Literature and Potential Research Opportunities. Technology Innovation Management Review, 10(1), 16–34. https://doi.org/10.22215/timreview/1311

Kim, J., Paek, B., & Lee, H. (2022). Exploring Innovation Ecosystem of Incumbents in the Face of Technological Discontinuities: Automobile Firms. Sustainability (Switzerland), 14(3). https://doi.org/10.3390/su14031606

Kim, K.-H. (2020). Coopetition: Complexity of Cooperation and Competition in Dyadic and Triadic Relationships. Organizational Dynamics, 49(2), 100683. https://doi.org/10.1016/j.orgdyn.2018.09.005

Kindermann, B., Salge, T. O., Wentzel, D., Flatten, T. C., & Antons, D. (2022). Dynamic capabilities for orchestrating digital innovation ecosystems: Conceptual integration and research opportunities. Information and Organization, 32(3), 100422. https://doi.org/10.1016/j.infoandorg.2022.100422

Klagge, B., Liu, Z., & Campos Silva, P. (2012). Constructing China's wind energy innovation system. Energy Policy, 50, 370–382. https://doi.org/10.1016/J.ENPOL.2012.07.033

Kwak, K., Kim, W., & Park, K. (2018). Complementary multiplatforms in the growing innovation ecosystem: Evidence from 3D printing technology. Technological Forecasting and Social Change, 136, 192–207. https://doi.org/10.1016/j.techfore.2017.06.022

Le Roy, F., Fernandez, A.-S., & Chiambaretto, P. (2018). From Strategizing Coopetition to Managing Coopetition. In A.-S. Fernandez, P. Chiambaretto, F. Le Roy, & W. Czakon (Eds.), The Routledge Companion to Coopetition Strategies (pp. 36–46). Routledge.
Leavy, B. (2012). Ron Adner: Managing the interdependencies and risks of an innovation ecosystem. Strategy and Leadership, 40(6), 14–21. https://doi.org/10.1108/10878571211278840
Letaifa, S. Ben. (2014). The uneasy transition from supply chains to ecosystems: The value-creation/value-capture dilemma. Management Decision, 52(2), 278–295. https://doi.org/10.1108/MD-06-2013-0329
Li, J., Chen, L., Yi, J., Mao, J., & Liao, J. (2019). Ecosystem-specific advantages in international digital commerce. Journal of International Business Studies, 50(9), 1448–1463. https://doi.org/10.1057/s41267-019-00263-3
Lingens, B., Böger, M., & Gassmann, O. (2021). Even a Small Conductor Can Lead a Large Orchestra: How Startups Orchestrate Ecosystems. California Management Review, 63(3), 118–143. https://doi.org/10.1177/00081256211005497
Liu, B., Shao, Y., Liu, G., & Ni, D. (2022). An Evolutionary Analysis of Relational Governance in an Innovation Ecosystem. SAGE Open, 12(2), 215824402210930. https://doi.org/10.1177/21582440221093044
Liu, Z., & Stephens, V. (2019). Exploring innovation ecosystem from the perspective of sustainability: Towards a conceptual framework. Journal of Open Innovation: Technology, Market, and Complexity, 5(48), 1–14. https://doi.org/10.3390/joitmc5030048
Luo, J. (2018). Architecture and Evolvability of Innovation Ecosystems. Technological Forecasting & Social Change, 136, 132–144. https://doi.org/10.1016/j.techfore.2017.06.033
Lusch, R. F., & Nambisan, S. (2015). Service Innovation A Service-Dominant Logic Perspective. MIS Quarterly, 39(1), 155–176. https://www.jstor.org/stable/26628345
Lusch, R. F., Vargo, S. L., & Gustafsson, A. (2016). Fostering a trans-disciplinary perspectives of service ecosystems. Journal of Business Research, 69(8), 2957–2963. https://doi.org/10.1016/J.JBUSRES.2016.02.028
Lütjen, H., Schultz, C., Tietze, F., & Urmetzer, F. (2019). Managing ecosystems for service innovation: A dynamic capability view. Journal of Business Research, 104, 506–519. https://doi.org/10.1016/j.jbusres.2019.06.001
Mäkinen, S. J., & Dedehayir, O. (2014). Business Ecosystems' Evolution — An Ecosystem Clockspeed Perspective. In Advances in Strategic Management (Vol. 30, pp. 99–125). https://doi.org/10.1108/S0742-3322(2013)0000030007
Malherbe, M., & Tellier, A. (2022). Explaining the nonalignment of ecosystem partners: A structuralist approach. Strategic Organization, 1–30. https://doi.org/10.1177/14761270221084224
Mantovani, A., & Ruiz-Aliseda, F. (2016). Equilibrium innovation ecosystems: The dark side of collaborating with complementors. Management Science, 62(2), 534–549. https://doi.org/10.1287/mnsc.2014.2140
Martin, B. R. (2016). Twenty challenges for innovation studies. Science and Public Policy, 43(3), 432–450. https://doi.org/10.1093/scipol/scv077
Moore, J. F. (1993). Predators and prey: a new ecology of competition. Harvard Business Review, 71(3), 75–86.
Moore, J. F. (1996). The Death of Competition - Leadership and Strategy in the Age of Business Ecosystems. HarperBusiness.
Moore, J. F. (2006). Business ecosystems and the view from the firm. The Antitrust Bulletin, 51(1), 31–75.
Morgan, D. L. (2014). Integrating Qualitative and Quantitative Methods: A Pragmatic Approach. Sage.
Nambisan, S., Siegel, D., & Kenney, M. (2018). On open innovation, platforms, and entrepreneurship. Strategic Entrepreneurship Journal, 12(3), 354–368. https://doi.org/10.1002/sej.1300
Nelson, R. R., & Winter, S. G. (1982). An Evolutionary Theory of Economic Change. The Belknap Press of Harvard University Press.
Nylund, P. A., Brem, A., & Agarwal, N. (2021). Innovation ecosystems for meeting sustainable development goals: The evolving roles of multinational enterprises. Journal of Cleaner Production, 281, 1–11. https://doi.org/10.1016/j.jclepro.2020.125329
Oh, D., Phillips, F., Park, S., & Lee, E. (2016). Innovation ecosystems: A critical examination. Technovation, 54, 1–6. https://doi.org/10.1016/j.technovation.2016.02.004
Ozalp, H., Cennamo, C., & Gawer, A. (2018). Disruption in Platform-Based Ecosystems. Journal of Management Studies, 55(7), 1203–1241. https://doi.org/10.1111/joms.12351
Panico, C., & Cennamo, C. (2020). User preferences and strategic interactions in platform ecosystems. Strategic Management Journal. https://doi.org/10.1002/smj.3149
Patton, M. Q. (2002). Qualitative evaluation and research methods (3rd ed.). Sage.
Peltoniemi, M. (2006). Preliminary theoretical framework for the study of business ecosystems. E:CO Emergence: Complexity and Organization, 8(1), 10–19.

Phillips, M. A., & Ritala, P. (2019). A complex adaptive systems agenda for ecosystem research methodology. Technological Forecasting & Social Change, 148, 119739. https://doi.org/10.1016/j.techfore.2019.119739

Pidun, U., Reeves, M., & Knust, N. (2022). Setting the Rules of the Road. MIT Sloan Management Review, 63(2), 44–50.

Pidun, U., Reeves, M., & Wesselink, E. (2021). How Healthy Is Your Business Ecosystem? MIT Sloan Management Review, 62(3), 31–38.

Pierce, C. S. (1878). Deduction, induction, and hypothesis. Popular Science Monthly, 13, 470–482.

Porter, M. E. (1985). The Competitive Advantage: Creating and Sustaining Superior Performance. Free Press.

Poulsen, T., & Hasager, C. B. (2017). The (R)evolution of China: Offshore wind diffusion. Energies, 10(12), 1–32. https://doi.org/10.3390/en10122153

Poulsen, T., & Lema, R. (2017). Is the supply chain ready for the green transformation? The case of offshore wind logistics. Renewable and Sustainable Energy Reviews, 73(February), 758–771. https://doi.org/10.1016/j.rser.2017.01.181

Radziwon, A., & Bogers, M. (2019). Open innovation in SMEs: Exploring inter-organizational relationships in an ecosystem. Technological Forecasting and Social Change, 146, 573–587. https://doi.org/10.1016/j.techfore.2018.04.021

Radziwon, A., Bogers, M., & Bilberg, A. (2017). Creating and capturing value in a regional innovation ecosystem: A study of how manufacturing SMEs develop collaborative solutions. International Journal of Technology Management, 75(1–4), 73–96. https://doi.org/10.1504/IJTM.2017.085694

Rai, R., Gnyawali, D. R., & Bhatt, H. (2022). Walking the Tightrope: Coopetition Capability Construct and Its Role in Value Creation. Journal of Management. https://doi.org/10.1177/01492063221107873

Randhawa, K., West, J., Skellern, K., & Josserand, E. (2020). Evolving a Value Chain to an Open Innovation Ecosystem: California Management Review, 1–34. https://doi.org/10.1177/0008125620974435

Ranganathan, R., Ghosh, A., & Rosenkopf, L. (2018). Competition-cooperation interplay during multifirm technology coordination: The effect of firm heterogeneity on conflict and consensus in a technology standards organization. Strategic Management Journal, 39(12, SI), 3193–3221. https://doi.org/10.1002/smj.2786

Reiss, M. (2011). Complementors Relationship Management - Missing Link in Supply Chain Management. In R. M. Samson (Ed.), Supply-Chain Management: Theories, Activities/Functions and Problems (Vol. 7280, Issue 216, pp. 139–156). Nova Science Publishers, Inc. http://ebookcentral.proquest.com/lib/aalborguniv-ebooks/detail.action?docID=3020056

Rietveld, J., Ploog, J. N., & Nieborg, D. B. (2020). Coevolution of Platform Dominance and Governance Strategies: Effects on Complementor Performance Outcomes. Academy of Management Discoveries, 6(3), 488–513. https://doi.org/10.5465/amd.2019.0064

Ritala, P., Aarikka-Stenroos, L., & Gnyawali, D. R. (2020). Co-Evolution of Ecosystem Value Proposition Across Institutional Fields: Longitudinal Case Study. Academy of Management Proceedings. https://doi.org/10.5465/AMBPP.2020.145

Ritala, P., Agouridas, V., Assimakopoulos, D., & Gies, O. (2013). Value creation and capture mechanisms in innovation ecosystems: A comparative case study. International Journal of Technology Management, 63(3–4), 244–267. https://doi.org/10.1504/IJTM.2013.056900

Ritala, P., & Almpanopoulou, A. (2017). In defense of 'eco' in innovation ecosystem. Technovation, 60–61(February), 39–42. https://doi.org/10.1016/j.technovation.2017.01.004

Ritala, P., Golnam, A., & Wegmann, A. (2014). Coopetition-based business models: The case of Amazon.com. Industrial Marketing Management, 43(2), 236–249. https://doi.org/10.1016/j.indmarman.2013.11.005

Ritala, P., & Gustafsson, R. (2018). Q&A. Innovation and Entrepreneurial Ecosystem Research: Where Are We Now and How Do We Move Forward? Technology Innovation Management Review, 8(7), 52–58.

Ritala, P., Kraus, S., & Bouncken, R. B. (2016). Introduction to coopetition and innovation: Contemporary topics and future research opportunities. International Journal of Technology Management, 71(1–2), 1–9. https://doi.org/10.1504/IJTM.2016.077985

Rohrbeck, R., Hölzle, K., & Gemünden, H. G. (2009). Opening up for competitive advantage - How Deutsche telekom creates an open innovation ecosystem. R&D Management, 39(4), 420–430. https://doi.org/10.1111/j.1467-9310.2009.00568.x

Rong, K., Wu, J., Shi, Y., & Guo, L. (2015). Nurturing business ecosystems for growth in a foreign market: Incubating, identifying and integrating stakeholders. Journal of International Management, 21(4), 293–308. https://doi.org/10.1016/j.intman.2015.07.004

Russo-Spena, T., Tregua, M., & Bifulco, F. (2017). Searching through the jungle of innovation conceptualisations System, network and ecosystem perspectives. Journal of Service Theory and Practice, 27(5, SI), 977–1005. https://doi.org/10.1108/JSTP-10-2015-0224

Saunders, M., Lewis, P., & Thornhill, A. (2012). Research Methods for Business Students. Pearson Education Ltd.

Schaarschmidt, M., Homscheid, D., & Kilian, T. (2019). Application Developer Engagement in Open Software Platforms: An Empirical Study of Apply iOS and Google Android Developers. International Journal of Innovation Management, 23(4), 1–33. https://doi.org/10.1142/S1363919619500336

Scholten, S., & Scholten, U. (2012). Platform-based Innovation Management: Directing External Innovational Efforts in Platform Ecosystems. Journal of the Knowledge Economy, 3(2), 164–184. https://doi.org/10.1007/s13132-011-0072-5

Schroth, F., & Häußermann, J. J. (2018). Collaboration Strategies in Innovation Ecosystems: An Empirical Study of the German Microelectronics and Photonics Industries. Technology Innovation Management Review, 8(11), 4–12. https://doi.org/10.22215/timreview/1195

Shipilov, A., & Gawer, A. (2020). Integrating Research on Interorganizational Networks and Ecosystems. Academy of Management Annals, 14(1), 92–121. https://doi.org/10.5465/annals.2018.0121

Shou, Y., Shi, Y., & Ren, G. J. (2022). Guest editorial: Deconstructing business ecosystems: complementarity, capabilities, co-creation and co-evolution. Industrial Management and Data Systems, 122(9), 1977–1986. https://doi.org/10.1108/IMDS-09-2022-811

Silverman, D. (2019). Doing Qualitative Research. SAGE Publications Ltd.

Snihur, Y., Thomas, L. D. W., & Burgelman, R. A. (2018). An Ecosystem-Level Process Model of Business Model Disruption: The Disruptor's Gambit. Journal of Management Studies, 55(7), 1278–1316. https://doi.org/10.1111/joms.12343

Song, J. (2016). Innovation ecosystem: impact of interactive patterns, member location and member heterogeneity on cooperative innovation performance. Innovation: Management, Policy and Practice, 18(1), 13–29. https://doi.org/10.1080/14479338.2016.1165624

Spigel, B., & Harrison, R. (2018). Toward a process theory of entrepreneurial ecosystems. Strategic Entrepreneurship Journal, 12(1), 151–168. https://doi.org/10.1002/SEJ.1268

Srinivasan, A., & Venkatraman, N. (2010). Indirect network effects and platform dominance in the video game industry: A network perspective. IEEE Transactions on Engineering Management, 57(4), 661–673. https://doi.org/10.1109/TEM.2009.2037738

Struckell, E., Ojha, D., Patel, P. C., & Dhir, A. (2021). Ecological determinants of smart home ecosystems: A coopetition framework. Technological Forecasting and Social Change, 173(September), 121147. https://doi.org/10.1016/j.techfore.2021.121147

Suddaby, R. (2006). From the Editors: What Grounded Theory is Not. Https://Doi.Org/10.5465/Amj.2006.22083020, 49(4), 633–642. https://doi.org/10.5465/AMJ.2006.22083020

Surie, G. (2017). Creating the innovation ecosystem for renewable energy via social entrepreneurship: Insights from India. Technological Forecasting and Social Change, 121, 184–195. https://doi.org/10.1016/J.TECHFORE.2017.03.006

Tansley, A. G. (1935). The Use and Abuse of Vegetational Concepts and Terms. Ecology, 16(3), 284–307.

Tavalaei, M. M., & Cennamo, C. (2021). In search of complementarities within and across platform ecosystems: Complementors' relative standing and performance in mobile apps ecosystems. Long Range Planning, 54(5), 101994. https://doi.org/10.1016/j.lrp.2020.101994

Teece, D. J. (1986). Profiting from technological innovation: Implications for integration, collaboration, licensing and public policy. Research Policy, 15, 285–305. https://doi.org/10.1142/9789812833181_0005

Thomas, L. D. W., & Autio, E. (2019). Innovation Ecosystems. Oxford Research Encyclopaedia of Business and Management.

Tiwana, A. (2015). Evolutionary competition in platform ecosystems. Information Systems Research, 26(2), 266–281. https://doi.org/10.1287/isre.2015.0573

Tsujimoto, M., Kajikawa, Y., Tomita, J., & Matsumoto, Y. (2018). A review of the ecosystem concept — Towards coherent ecosystem design. Technological Forecasting and Social Change, 136, 49–58. https://doi.org/10.1016/j.techfore.2017.06.032

Valkokari, K. (2015). Business, Innovation, and Knowledge Ecosystems: How They Differ and How to Survive and Thrive within Them. Technology Innovation Management Review, 5(8), 17–24. https://doi.org/10.22215/timreview919

van der Borgh, M., Cloodt, M., & Romme, A. G. L. (2012). Value creation by knowledge-based ecosystems: evidence from a field study. R&D Management, 42(2), 150–169.

Velu, C. (2015). Knowledge management capabilities of lead firms in innovation ecosystems. AMS Review, 5(3–4), 123–141. https://doi.org/10.1007/s13162-015-0068-6

Venkatraman, N., & Lee, C. (2004). Preferential Linkage and Network Evolution: A Conceptual Model and Empirical Test in the U.S. Video Game Sector. Academy of Management Journal, 47(6), 876–892.

Volberda, H. W., & Lewin, A. Y. (2003). Guest Editors' Introduction: Co-evolutionary Dynamics within and between Firms: From Evolution to Co-evolution. Journal of Management Studies, 40(8), 2111–2136. https://doi.org/10.1046/j.1467-6486.2003.00414.x

Walrave, B., Talmar, M., Podoynitsyna, K. S., Romme, A. G. L., & Verbong, G. P. J. (2018). A multi-level perspective on innovation ecosystems for path-breaking innovation. Technological Forecasting and Social Change, 136(November), 103–113. https://doi.org/10.1016/j.techfore.2017.04.011

Wang, R. D., & Miller, C. D. (2020). Complementors' engagement in an ecosystem: A study of publishers' e-book offerings on Amazon Kindle. Strategic Management Journal, 41(1), 3–26. https://doi.org/10.1002/smj.3076

Wareham, J., Fox, P. B., & Giner, J. L. C. (2014). Technology ecosystem governance. Organization Science, 25(4), 1195–1215. https://doi.org/10.1287/orsc.2014.0895

Wegmann, A., Ritala, P., Tapandjieva, G., & Golnam, A. (2018). Coopetition and Ecosystems: The Case of Amazon.com. In A.-S. Fernandez, P. Chiambaretto, F. Le Roy, & W. Czakon (Eds.), The Routledge Companion to Coopetition Strategies (pp. 245–257). Routledge.

Wilhelm, M., & Sydow, J. (2018). Managing Coopetition in Supplier Networks – A Paradox Perspective. Journal of Supply Chain Management, 54(3), 22–41. https://doi.org/10.1111/jscm.12167

Williamson, P. J., & De Meyer, A. (2012). Ecosystem advantage: How to successfully harness the power of partners. California Management Review, 55(1), 24–46. https://doi.org/10.1525/cmr.2012.55.1.24

Williamson, R. (2023, February 9). Wind turbine failure rates are rising – has the industry gone too big, too fast? | RenewEconomy. Renew Economy. https://reneweconomy.com.au/wind-turbine-failure-rates-are-rising-has-the-industry-gone-too-big-too-fast/

WindEurope. (2021). Ports as Key Players in the Offshore Wind Supply Chain (Issue May). https://windeurope.org/intelligence-platform/product/ports-as-key-players-in-the-offshore-wind-supply-chain/

Xu, G., Wu, Y., Minshall, T., & Zhou, Y. (2018). Exploring innovation ecosystems across science, technology, and business: A case of 3D printing in China. Technological Forecasting and Social Change, 136, 208–221. https://doi.org/10.1016/j.techfore.2017.06.030

Xu, Y., Hazée, S., So, K. K. F., Li, K. D., & Malthouse, E. C. (2021). An evolutionary perspective on the dynamics of service platform ecosystems for the sharing economy. Journal of Business Research, 135, 127–136. https://doi.org/10.1016/j.jbusres.2021.05.056

Yin, R. K. (2018). Case study research and applications: design and methods (6. edition.) [Book]. SAGE Publications, Inc.

Yoffie, D. B., & Kwak, M. (2006). With Friends like These: The Art of Managing Complementors. Harvard Business Review, September, 88–98.

Yoo, D. K., Roh, J. J., Cho, S., & Yang, M. M. (2022). Coopetition in a platform ecosystem: from the complementors' perspective. Electronic Commerce Research. https://doi.org/10.1007/s10660-022-09565-5

Zahra, S. A., & Nambisan, S. (2011). Entrepreneurship in global innovation ecosystems. AMS Review, 1(1), 4–17. https://doi.org/10.1007/s13162-011-0004-3

Zhang, H., Hu, Y., Shi, X., & Gao, Y. (2022). When and how do innovation ecosystems outperform integrated organizations? On technological interdependencies and ecosystem performance. Industrial Management and Data Systems. https://doi.org/10.1108/IMDS-11-2021-0720

Zhu, F. (2019). Friends or foes? Examining platform owners' entry into complementors' spaces. Journal of Economics and Management Strategy, 28(1), 23–28. https://doi.org/10.1111/jems.12303

Zhu, F., & Iansiti, M. (2012). Entry into Platform-Based Markets. Strategic Management Journal, 33(September 2009), 88–106. https://doi.org/10.1002/smj.941

Zhu, F., & Liu, Q. (2018). Competing with complementors: An empirical look at Amazon.com. Strategic Management Journal, 39(10), 2618–2642. https://doi.org/10.1002/smj.2932

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