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ORIGINAL PAPER

How are actor dynamics balanced in ecosystems? An in-depth case study of an autonomous maritime transportation ecosystem

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Abstract
Numerous studies have investigated the formation of network relationships, but few have addressed the actual process of maintaining balance in interorganizational dynamics of networks. Even more, the topic has remained largely unexplored in the context of *ecosystems,* where simultaneous alignment of multiple actors is needed. This paper advances understanding on ecosystems' actor alignment from a network dynamics perspective. Through an in-depth single case study, the paper reviews how the case ecosystem was orchestrated to create more safe, sustainable, and intelligent maritime transportation industry and how a balance in the interplay among its members was maintained. Our results reveal a nonlinear evolution process of ecosystems, complementing earlier discussion on ecosystems' lifecycle through centripetal (constructive) and centrifugal (destructive) forces that influence actor dynamics. With the evidence from our case, we conclude that structural design choices and contextual alignment mechanisms are essential to balance the emergent forces. We find four alignment mechanisms that ecosystem orchestrators can leverage: (i) *complementation:* driving network effects from idiosyncratic asset providers, (ii) *neutral orchestration:* stabilizing trust and sharing, (iii) *reconfiguration:* reshaping of the ecosystem's targets to maintain a common objective, and (iv) *restructuring:* coordination activity to shape the required skills to meet the ecosystem's vision. We further suggest an elaboration to generic ecosystem roles – the role of "leading complementors" or "key complementors", to distinguish them from generic complementors.

Keywords Inter-firm dynamics · Ecosystem collaboration · Ecosystem alignment · Ecosystem actor alignment · Market-shaping

JEL Classification L14 · 032

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1 Introduction

Amidst grand challenges of our times, such as environmental degradation and climate change, new and more effective means for organizing businesses more sustainably are urgently needed to address the systemic and global challenges in a timely manner. Over the past decade, *ecosystems* in business have emerged as an additional concept advancing the network perspective of firms (e.g., Möller et al. 2005), allowing a large number of industrial players to position themselves into the context of a particular grand challenge. The concept encompasses networks of independent yet interdependent organizations driving value creation through cooperation, creativity, and exchange of activities, fueling the expansion and blending of firm and industrial boundaries (Ruiz-Alba et al. 2021; Aarikka-Stenroos and Ritala 2017).

Ecosystems produce outcomes that are greater than any of its individual participants could deliver alone, creating a synergetic outcome (Aarikka-Steenroos and Ritala 2017; Thomas and Tee 2022). They do not predominantly rely on the forms of hierarchical control such as market-based contracts (e.g., Jacobides et al. 2018), but rather incorporate several co-existing coordination mechanisms including bilateral contracts, multilateral negotiations, standards, platforms, and systems integration (Holgersson et al. 2022). Thus, the ecosystem concept exhibits distinct interorganizational dynamics in contrast to other types of networks which often rely on hierarchical control defined by contracts, such as strategic alliances or supply networks (e.g., Tsujimoto et al. 2018). Literature proposes that the capabilities of ecosystems' members co-evolve over time around a common purpose (Iansiti and Levien 2004) or a platform (e.g., Jacobides et al. 2018). The co-evolution process involves collaboration among discrete entities or organizations, where conflicting and synergistic interests can co-exist. To maintain the co-evolution trajectory and continuous value delivery, a balance of centripetal and centrifugal forces, that are either constructive or destructive in nature, needs to be led and managed by an ecosystem orchestrator (Holgersson et al. 2022). One of the core challenges ecosystem orchestrators face thus relates to actor alignment (Adner 2017). We find that this has received lesser attention in academic studies.

Actor alignment presents an opportunity to enhance our understanding of how the influence and impact of an actor's individual decision can be balanced by an ecosystem orchestrator. While prior research has agreed on the patterns of ecosystem evolution as a linear process (e.g., Moore 1996; Letaifa 2014; Rong and Shi 2014; Autio 2021), research is lacking understanding on the mechanisms how ecosystems' collective purpose is met from actor alignment perspective. This understanding is a vital element for comprehending the functioning and development of ecosystems in the absence of hierarchical control.

This study sets out to address the problem of actor alignment and explores how the centripetal (constructive) and centrifugal (destructive) forces are balanced by the efforts of ecosystem orchestrators. We conduct an in-depth case study to explore how balance in interorganizational dynamics is maintained over ecosystems' evolution. For that, we address two research questions:

RQ1: How do constructive (centripetal) and destructive (centrifugal) forces appear in ecosystems' evolution?
RQ2: What mechanisms are employed to maintain the balance of forces in ecosystems?

The study focuses on a case ecosystem in the maritime transportation industry, in which some of the leading industrialists are seeking collaborative means to enable the creation of a safer and more sustainable maritime transport operations with the help of digitalization. The maritime transportation industry today presents a significantly large portion of the world's overall economic activity with a constantly increasing demand—the global transportation volumes of goods by sea are expected to be tripled by 2050. The industry has, thus, a strategic direction to integrate new technologies to foster safety, operational efficiency, sustainability and address environmental impact of the operations (IMO 2019). The variety of actors involved in the studied ecosystem offers an opportunity to understand the mechanisms for value creation and value capture for all the ecosystem actors (Tsvetkova and Hellström 2022) shaping the industry into more efficient and sustainable. Prior studies on mobility and transportation (e.g., Cabanelas et al. 2023), and autonomous vehicles (e.g., Turienzo et al. 2023) have shown advantages of collaborative ecosystems in terms of accessing a broader variety of actors in mobility networks, including initially competing players. However, this paper is aimed at answering to the management research "backlog" in the context of Industry 4.0., from the perspective of cooperation and networks, change and leadership (Schneider 2018), and how ecosystems are led to shape future industries.

The study is structured as follows. First, the paper offers a literature review on the characteristics of ecosystems, their interorganizational dynamics, actor alignment, and different roles. Then, the theoretical background and framework of the study is presented. The study is anchored to the transaction cost economics (TCE) theory by Williamson (1998) and balance theory (Cartwright and Harary 1977). The framework we propose operationalizes how the interorganizational dynamics through centripetal and centrifugal forces emerge in the context of open-innovation and joint product development. Then, we present the in-depth case study method and our data analysis, followed by a discussion on research implications for practice and academia.

2 Literature review

Literature posits that ecosystems are networks of organizations comprising a diverse set of actors in which the expertise extends beyond a single industry, domain, or sector (Moore 1993). The concept deviates from generally studied networks as an ecosystem's structure is characterized by *shared interdependencies* among its actors and co-evolution (Adner 2017). The interdependencies and synergies (Hienerth et al. 2014) are maintained by an alignment structure of the ecosystem (Adner 2017) under which each actor generates and extracts value from the interorganizational work. As no actor has direct hierarchical control over one

another (Jacobides et al. 2018), this characteristic induces particular dynamics for the entire system as all actors behave under their own rationality and decision-making principles (Tsujimoto et al. 2018). However, there is scarce evidence how a balance in dynamics is maintained.

Literature has identified that ecosystem architecture is an important aspect of ecosystems' management because it can impact the efficiency, effectiveness, and overall success of an ecosystem. For example, it has been proposed that a well-designed ecosystem architecture has designated pathways to the creation and commercialization of new ideas and innovations. According to Dattee et al. (2018), the designed architecture includes generic ecosystem roles, a vision that defines the overall value proposition, and that the structure defines the mechanisms for value capture. The design is important since every actor maintains residual control and claims over their individual assets (Jacobides et al. 2018) and, therefore, guides the collaborative effort.

In line with Dattee et al. (2018), Adner (2017) characterizes the alignment structure as an agreement in the flows of activities and positions within an ecosystem. The firm-level connections in ecosystems' alignment structure are often based on *complementarity* or *idiosyncrasies* that drive the emergence of synergies (Jacobides et al. 2018) but which does not limit the possible conflict of interests (Holgersson et al. 2022). Thereby, aligning the complementing parties on the overall objectives is rather broad and complex task since each party has their own rationality (Tsujimoto et al. 2018).

Ecosystems are distinguished from other structural arrangements for value co-production by the nature of their governance and coordination challenges (Autio 2021). As there might co-exist competing views, especially on how the value is appropriated among the ecosystem's members, ecosystems follow various coordination mechanisms. These include bilateral contracts, multilateral negotiations, standards, platforms, and systems integration (Holgersson et al. 2022). To mediate the above described task for maintaining balance, prior literature proposes the activity for aligning complementarities through *ecosystem orchestration* (Kapoor 2018) or governance (Dhanaraj and Parhe 2006). In ecosystem orchestration, the goal is to align complementing parties with idiosyncratic skills and capabilities by managing the relationships of distinct organizations towards the collective goal (Williamson and De Meyer 2012).

The role of ecosystem orchestrators is to seek ways to deliver more value than the parts would deliver alone. Teece (2007) defines orchestration with the following managerial activities: *coordination* and *integration*, *learning and reconfiguration*. Strategically, an orchestrator attempts to enhance value creation by coordinating complementors and aligning them in a way that the combination of their complementarities would be the most valuable (Teece 2007); in practice, orchestration pulls together dispersed resources and capabilities of network members, creating value, and at the same time defines rules for extracting value from the network for its actors (Kapoor 2018; Dhanaraj and Parkhe 2006). Prior literature finds that ecosystems' failure can lie in the governance of an ecosystem (Cui et al. 2022), thus calling for better understanding on their coordination mechanisms.

In addition to the orchestrator's role, literature has identified other generic ecosystem roles (Table 1). In many cases, the end-customer may not only pay for tangible asset, but also for its functionality, accessibility and associated value-added services and thus distinct roles are required to fulfill the overall objective (Schneider 2018). Complementors are considered as the "core ecosystem partners", as they have mutual benefits by sharing dependencies with one another (Linde et al. 2021, p.7). Another role is the keystone player or a lead company. Iansiti and Levien (2004) argue that keystone players have a crucial position in the ecosystem as withdrawal of a keystone player would potentially lead to a dissolution of the whole ecosystem. The keystone players are often the first ones to attract the complementors and to drive the value creation process. The challenge for keystone players is value sharing, as they tend to have a dominating role in the value creation process – without keystone players ecosystems would risk of ceasing to exist (Iansiti and Levien 2004; Moore 1993). In this vein, Linde et al. (2021) find that ecosystem's leading actors have the tendency to dictate the agenda and set the roles and responsibilities in the ecosystem. However, if the keystone player fails to share value with other ecosystem members, it risks causing other ecosystem partners to abandon the network, jeopardizing the system's ability to generate future value (Iansiti and Levien 2004). Jacobides (2018, p. 2263) talk about "powerful firms". The powerful firms are "hubs" in their position to lead, dictate rules and timing, and create the processes for the ecosystem for complementors to follow (Adner 2017; Jacobides et al. 2018). According to Williamson and De Meyer (2012, p.33) a lead firm uses its power in "stimulating and shaping" the ecosystem around it. This lead firm is not always "the largest or most resource-rich participant". Notably, the leadership position can be also shared by a number of firms, which is then considered as "shared leadership" (Adner 2017, p.48). In addition to above-discussed roles, an ecosystem might have a funding party or a sponsor. The sponsor's role might have varying definitions across the different ecosystem conceptualizations (e.g., platform vs. innovation ecosystem). In that regard, literature has found that the role of sponsors can be to offer financial incentives for the ecosystem or provide risk-funding, as described later in our case (see e.g., Ceccagnoli et al. 2012; Jacobides et al. 2018).

Due to the fact that ecosystems entail a variety of actors that are independent, diverging interests among ecosystem's members may emerge. Group dynamics encompasses several possibilities that include conflicts, mistrust, and isolation of the actors. Organizational interaction is thus a natural viewpoint for understanding how firms manage multilateral alignment (Adner 2017). The focus of such avenue is to understand the influence of interorganizational dynamics when ecosystem members collaborate, compete, and coopete (e.g., Tsujimoto et al. 2018; Jacobides et al. 2018). As discussed, the difficulty is that the actors need to be retained in alignment without hierarchy; the value appropriation logic needs to be fair, and the ecosystem needs to provide appropriate incentives for all affiliated parties (Jacobides et al. 2018).

Table 1 Generic roles in ecosystems

Ecosystem roles in literature	Description of the role in literature	Literature for the role
Ecosystem orchestrator	Engages in multi-sided conversations with prospective ecosystem participants to co-discover architecture for an ecosystem	Autio (2021) Cui et al. (2022) Dhanaraj and Parkhe (2006) Jacobides et al. (2018)
Keystone/hub firm	Increases ecosystem productivity by simplifying the connection between ecosystem participants (e.g., technology platform provider)	Iansiti and Levien (2004) Jacobides et al. (2018) Linde et al. (2021)
Niche firm	Develops specialized capabilities which bring diversity; the ecosystem might depend on a niche	Iansiti and Levien (2004)
Complementor	Complementors share capabilities that are beneficially used only if combined	Jacobides et al. (2018)
Sponsor	Offers risk-funding and incentives for the ecosystem (e.g., risk-funding or tax credit by public authorities)	Amezcua et al. (2013) Ceccagnoli et al. (2012) Gosline and Krithivasan (2021)
Leading company	The one who will attempt to guide the transition and shaping the ecosystem	Adner (2017) Williamson and De Meyer (2012)
Collaborator/follower	Parties that agree to act in accordance with leader's plan	Adner (2017) Gosline and Krithivasan (2021)
Anchor	A role that bridges different industries together for a seamless customer journey (e.g., identification service)	Gosline and Krithivasan (2021)

3 Theoretical background and framework

Figure 1 describes the theoretical framework of the paper, in which TCE by Williamson (1986) is our overarching theory. The TCE theory argues that firms seek to minimize their subjective transaction costs. In the context of ecosystems, decision-making based on transaction costs leads to the emergence or dissolution of ecosystems, through a motive to form or cease collaborative relationships. In this paper, we detail the idea how ecosystems evolve by using Balance theory (Cartwright and Harary 1977), which explains why orchestrators need to use ecosystem-level alignment mechanisms to even out imbalances in firms' transaction costs- and relational rents-based evaluations. In particular, the balancing acts (or alignment mechanisms) are needed as each ecosystem member is operating under their own decision-making principles and rationale (Tsujimoto et al. 2018), causing constructive (centripetal) or destructive (centrifugal) forces within the ecosystem (Holgersson et al. 2022).

3.1 Centripetal and centrifugal forces

Ecosystems emerge when there are benefits for both autonomy and coordination (Holgersson et al. 2022). However, according to Holgersson et al. (2022), the evolution of an ecosystem is the result of a shift in *balance of forces* that bring the actors of an ecosystem towards integration or pull its units apart. These forces are therefore either 'destructive' or 'constructive' in nature.

The constructive forces that bring actors together towards integration are called "centripetal forces" (Holgersson et al. 2022, p. 7). The main driver of such a force is complementarity. The stronger the actors' capabilities or outputs complement one another, or when the combined value offering is almost impossible to imagine

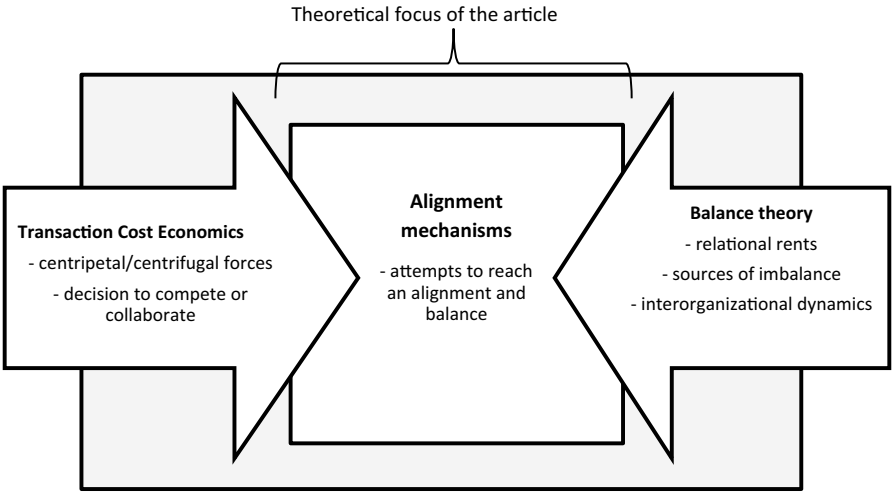


Fig. 1 Theoretical framework of the article

without the other (e.g., Jacobides et al. 2018), the more tendency there is to integrate the distinct capabilities to work together for mutual benefit. From TCE viewpoint, it is therefore natural for firms to seek minimizing their subjective transaction costs by expanding their competencies through networks, and ultimately, increase the shareable benefits through networked collaboration. Some opportunities are simply too large to be addressed with firm-level resources, and therefore ecosystems serve as a suitable vehicle.

On the contrary, there are destructive powers that pull ecosystems' actors apart. These are called "centrifugal" forces (Holgersson et al. 2022, p. 8). From TCE viewpoint, conflicting strategic interests are an exemplary source of a centrifugal force, as well as dispersed knowledge and information that is kept in secrecy from other ecosystem actors. More generally, opportunistic behavior can create tensions among ecosystem members that need to be adequately managed through orchestration. Especially in collaborative innovations, parties might have varying views on how potential earnings are fairly shared (Hanson and Henkel 2020). Additionally, when investments in the actual collaboration are made, firms can learn how to capture (appropriate) more value and try to avoid sharing the value for their own benefit.

3.2 Balance theory and relational rents

Balance theory has its foundations in sociological studies and it can be used to observe how e.g., individuals or organizations try to address relational inequity or mistrust among the network members in an unbalanced state until it becomes resolved (Choi and Wu 2009). In ecosystems, the interorganizational relationships are affected both by centrifugal and centripetal forces through the choices and behavior of each firm, which, in turn, influence the course of development of ecosystems. If the balance of forces shifts towards an unbalanced state, there is an urging need to reach the balance again through re-alignment of the actors. The role of an ecosystem orchestrator is to balance this.

The changes in the balance of forces among the ecosystem's players are dependent on the relational rents that the actors can gain from a collaborative ecosystem setting (Holgersson et al. 2022). Relational rents describe the relational value for collaboration with other independent parties that take part in the ecosystem. Dyer and Singh (1998) characterize relational rents as a jointly generated *supernormal profit* which is created by idiosyncratic contributions of the specific network partners. The authors explain that relational rents emerge when the network employs effective governance mechanisms that lower transaction costs or allow realization of synergies.

The concept of relational rents (Dyer and Singh 1998) can be used to explain the evolution from industry and firm-based competition to networks as there is more broad resource-base to influence the markets. Recently, this transition has been visible in ecosystems, where firms are seeking to *make the value of collaboration greater than the parts alone* through a joint operating mode and alignment structure. Prior studies, such as Cabanelas et al. (2023) conclude that an ability to work in collaborative ecosystems is also dynamic capability, especially in the transportation and mobility context. In this

setting, individual firms combine, exchange, or invest in idiosyncratic assets, knowledge, resources, and capabilities to realize synergies without hierarchical ownership structures.

3.3 Alignment mechanisms

Ecosystems can be understood as social architectures in which independent, yet interdependent firms are able to access a wider array of external resources (Alam et al. 2022b). The capacity of ecosystems to create value is thus largely determined by the successful interaction between its actors and the effective management of external resources beyond the scope of a single firm. To manage ecosystems' resource base efficiently, Adner (2017) highlights the importance of actor alignment for achieving the ecosystem's objectives. This process, known as *multilateral alignment,* diverges from traditional firm-centric management philosophy by involving the alignment of multiple individual organizations through various mechanisms, such as bilateral contracts, multilateral negotiations, standards, platforms, and systems integration (Holgersson et al. 2022).

Indeed, an orchestrator has a critical role in ensuring the functionality and longevity of an ecosystem (Cui et al. 2022). One of the primary challenges for ecosystem management is securing that the requisite complementary capabilities and skills are present in the ecosystem to realize the joint value proposition. As the ecosystems evolve, additional challenge is maintaining actor commitment over time. This coordination and alignment task is different from firm-controlled chains due to the absence of hierarchical governance as well as the economic interdependence of ecosystem members (Jacobides et al. 2018).

Ecosystem orchestration should balance its actors' relationships under various forces as ecosystems encompass elements of collaboration, direct competition, and coopetition (Moore 1999). Furthermore, under the own rationality of each participant (Tsujimoto et al. 2018), the relational rents of each member are subjective and determined by the ecosystem's alignment structure (Holgersson et al. 2021; Singh and Dyer 1998). One of the most important tasks for the orchestrator is reaching alignment of the ecosystem actors through *alignment mechanisms*.

The alignment structure, as defined by Adner (2017), characterizes an agreement in the flows and positions within an ecosystem. Alignment configuration is the state of balance in the ecosystem, when actors have congruent view on their own role, partners' roles, ecosystem's objectives, and processes in the ecosystem. In order to gain subjective relational rents (Dyer and Singh 1998) and to lower transaction costs (Williamson 1986) from the collaborative activities in the ecosystem, tensions and disagreements need to be solved (Choi and Wu 2009). For this reason, the alignment mechanisms are an essential tool an orchestrator has to leverage to maintain balance in an ecosystem.

3.4 Interorganizational dynamics

According to Lehman-Willenbrock et al. (2018), social interaction is captured in behavior that concerns the observable movements, interactions, and communications

groups engage in. Interorganizational behavior in ecosystems is opposed to *ego-systems*, in which firms follow a closed strategy, and seek to create rivalry, competition, and domination over other actors by protecting information and creating barriers. An ecosystem emphasizes an inter-firm openness strategy with high level of trust and transparent communication mechanisms (Alam et al. 2022a). The open strategy can complement the traditionally firm-centered business strategies (Chesbrough and Appleyard 2007).

This study follows inter-firm openness variables (Alam et al. 2022a) in an open innovation setting. Figure 2 describes our inter-firm openness dimensions framework in open innovation context by Alam et al. (2022b), which includes (1) trust, (2) collaboration, (3) sharing, (4) transparency, and (5) risk-taking. We use the inter-firm openness dimensions as a proxy to qualitatively describe and analyze interorganizational dynamics in the case ecosystem. The dimensions are strongly intertwined with one another, and a cause or effect cannot necessarily be assigned. For example, inter-firm trust can be the cause as well as the effect of transparency and knowledge sharing among firms (Alam et al. 2022b).

In our framework, trust refers to a reliance on partners' abilities, competences and interests (Alam et al. 2022b). It makes relationships long-lasting and reliable (Williamson and De Meyer 2012). Higher levels of interorganizational trust positively influence on the duration of partnership (Zhong et al. 2017) and also reduction of transaction costs (Williamson and De Meyer 2012). Alam et al. (2022b) further emphasize the importance of collaboration among the companies, implying a joint intention to work together with the needed composition of ecosystem members. With trustworthy and reliable partners, the open strategy (Chesbrough and Appleyard 2007) becomes viable in practice. It is the manifestation of reciprocal beliefs on the intentions of other ecosystem partners to realize both the shared and individual benefits. The open environment also creates possibilities for sharing complementary resources and makes them available for other ecosystem members (Zhong et al. 2017; Alam et al. 2022b). Finally, sharing is supported by transparency of all the ecosystem members, which means visibility and openness in terms of information

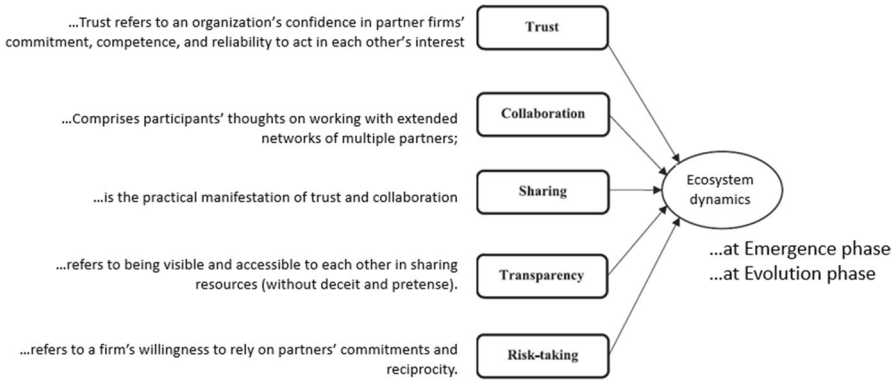


Fig. 2 Inter-firm variables (adapted from Alam et al. 2022a) used as a proxy to evaluate intraorganizational dynamics

flows, processes and costs of the activities related to the ecosystem. It creates a reciprocity effect in the ecosystem (Alam et al. 2022b). This makes open environment appealing to develop innovations and encourage investing in more risky ideas that wouldn't be realized by companies' own efforts (Alam et al. 2022b) sometimes known as "market-shaping".

4 Methodology

4.1 In-depth case study method

Ecosystems are highly contextual from research point of view; the objectives of each ecosystem are unique, and there is no alike compositions or evolution process. Research thus requires in-depth observations over ecosystems' dynamic evolution or extinction (Tsujimoto et al. 2018). In this paper, *an in-depth single case study method* is utilized to describe and analyze the interfirm dynamics of the case ecosystem's actors. Based on qualitative research design, this study allows examination of the phenomenon of dynamics in its all richness (Yin 2018) from the various perspectives of the case ecosystem's actors. Moreover, the method allows identifying *mechanisms* how balance in interorganizational dynamics is maintained in the system.

Our single case study has multiple subunits within the single case. Each of the subunits embedded in the study has a piece of relevant data on the whole case (Yin 2018). The case observes the perspectives of the key companies and organizations involved in the autonomous transportation ecosystem. Each actor possessed subjective views on the ecosystem's evolution, its interorganizational dynamics and balancing acts. The goal of this case study is thus to provide objective vantage point on the case from all the embedded subunits (Yin 2018) and to shed light how ecosystems can advance their collective aims by maintaining positive dynamics. In our case, the objective is the development of a more intelligent and sustainable maritime transportation industry.

Tsujimoto et al. (2018) discussed that event historical views are important for understanding ecosystems' evolution or extinction. In this single case study, the data is gathered from a backwards-looking perspective addressing the ecosystem's dynamic evolution. In our analysis, we follow the guidelines of Gioia et al. (2013) to provide qualitative rigor. With the abductive reasoning approach, we are "not guided by a priori theoretical considerations," but the goal is to introduce new concepts and frameworks, not limited by the existing theories (Ketokivi and Choi 2014, p.236).

Next, we describe the case ecosystem and the data collection and analysis, followed by the qualitative rigor.

4.2 Description of the case – autonomous maritime transportation ecosystem

The case ecosystem started to form in 2015 with its vision to advance the development of autonomous maritime transportation industry in conjunction with the

leading technology companies who shared maritime-related business interests. Common motivations for all the founding members were a strong eco-drive to jointly reduce the sector's environmental impact and intentions to improve the sector's overall efficiency.

Nowadays ships account for around 90% of the global goods transportation and the industry is being responsible for around 30% of NO_x emissions and 3% of global CO_2 emissions respectively. The ecosystem actors saw that maritime safety could also potentially be significantly improved, since human errors have still remained the most common reason of maritime related accidents, such as due to lack of situational awareness (OECD 2022; IMO 2019).

The founding members of the ecosystem were globally recognized industrial manufacturing and service firms, and digital technology innovators, ranging from machinery manufacturing and vessel building, information and communication technology (ICT), and engineering. Each company is a pioneer in their own field with a diverse expertise in the maritime industry.

The ecosystem was initially supported by a public funding organization as an effort to accelerate exports growth by attracting complementary innovators to introduce autonomous technologies for the industry. The ecosystem was chosen to be coordinated by an external neutral party – a co-creation facilitator organization consisting of a broad network of professionals and co-creation experts.

The story of the case ecosystem illustrates a unique development path over the years of its evolution. The case selection is motivated as empirical studies on ecosystems are scarce, and our case allows the discovery of new and practically relevant insight on interorganizational dynamics aside the extensive and abundant body of digital platform-focused literature.

4.3 Data collection and analysis

The collection of data and analysis were carried out according to case study guidelines proposed by Yin (2018), and qualitative rigor practices by Gioia et al. (2013). Our primary source of data was the broad array of the ecosystem representatives, ranging from a public innovation agency, industrial engineering and service companies, machine builders, and niche digital innovators.

Six key organizations of the ecosystem were interviewed in an in-depth semi-structured interview format. As some of the organizations had more than one actively engaged ecosystem representative, the total interviewee count amounted to nine different interviews. The nine interviewees were identified as key decision-makers of their respective organizations through snowballing technique. Finally, the validity of our interviewees was cross-confirmed during the interviews.

The interviews resulted into 87 pages of transcribed interview data from the total of 548 min of semi-structured interview discussions. Data triangulation practice using website data, press releases, and other publicly available information was followed to validate and further elaborate parts of the data (Table 2).

In the interviews, the logic of semi-structured interviews was followed, as they are more flexible, and as the questions could be adjusted for each interviewee's role.

The participants were given extraordinary voice to provide their best insight (Gioia et al. 2013). Preliminary list of themes was followed with slight variations in the interview questions, depending on the interviewee's role in the ecosystem, length of expertise in the ecosystem, and experience of unique events (Saunders et al. 2009).

The interview themes were constructed based on the inter-firm openness variables proposed by Alam et al. (2022b). The followed interview patterns aimed at describing first the story of the ecosystem, then revealing challenges of working in an open innovation setting, and finally to disclose the emergent interfirm dynamics over time in the light of inter-firm openness framework (see Fig. 2). For reference, Appendix 1 outlines our semi-structured interview format in detail.

The interviews took place online in bilateral meetings, in which both corresponding authors were present to avoid individual biases. Over the course of the research, interviews were recorded and transcribed for detailed analysis. A research database consisting of a list of interviewees, interview transcriptions, supplementary data, observations, and findings was built for making the analysis.

Below in Table 3, the primary data sources are described, with descriptive information of the interviewees.

In the analysis, the story of the ecosystem was first plotted in a timeline that captured the main events that occurred in the ecosystem's evolution process. This included major milestones, such as establishing the ecosystem as a foundation, leaving of an ecosystem partner, and major changes in objectives. Part 5.1. elaborates on the dynamics based on the timeline.

The data analysis was carried in two parts. First, a preliminary analysis was done, followed by a recurring process of getting back to theory and data (Morse et al. 2002). Second, the preliminary analysis was elaborated with help of a data structure to show how the conclusions were made (Gioia et al. 2013). The data analysis continued by aggregating the data into a unifying sheet, in which the ecosystem's events and dynamics dimensions were coded according to forces (centripetal and centrifugal), identified relational imbalances among the actors, and sources of relational rents. Using logical reasoning, we concluded how the emergent interorganizational dynamics affected the evolution of the ecosystem. Figure 3 shows the data analysis process followed in the study.

The detailed guidelines of Gioia et al. (2013) were followed to provide necessary qualitative rigor. Conclusions about how the ecosystem was able to maintain a balance among its actors were drawn abductively. We visualized the data structure of our analysis (Fig. 4), which provides a graphic representation of how we progressed from raw data to the terms and themes of the analyses.

Table 2 Sources of data

Sources of data	Pages
Interviews	87
Website data	15
Press releases	4
Other openly available data	98

Table 3 Description of interviews

	Position	Role in the ecosystem	Interview duration, minutes	Transcribed text, pages	Length of service in the ecosystem
1	Head of regulatory and public affairs	Company A	75	8	2015 – 2019
2	Head of (an) innovation ecosystem program	Company A	55	9	2019 – current
3	Chief Executive Officer	Orchestrator	60	9	2015 – current
4	Ecosystem lead	Orchestrator	65	12	2015 – 2019
5	Head of maritime affairs	Company B	45	8	2019 – current
6	Head of Innovation & Technology	Company C	58	12	2013 – 2019
7	Ecosystem Lead	Funding organization	25	4	2015 – current
8	Director, Networking businesses and research	Funding organization	90	13	2015 – current
9	Chief Executive Officer	Company D	75	12	2015 – 2019

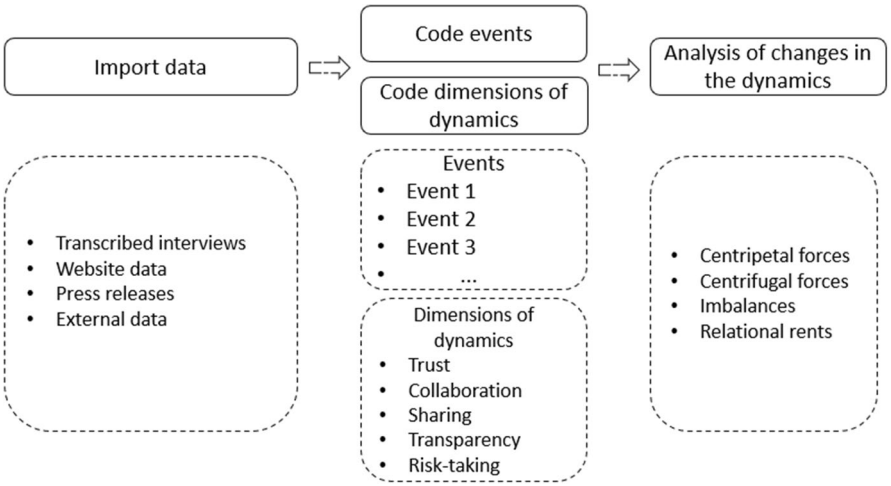


Fig. 3 The data analysis process

5 Results

5.1 Interorganizational dynamics and balancing efforts over the case ecosystem's evolution

The evolution of the case ecosystem was a unique development path that it went through over the years 2015–2022. The ecosystem overcame a number of challenges, starting from the emergence of the ecosystem, changing its structure, and

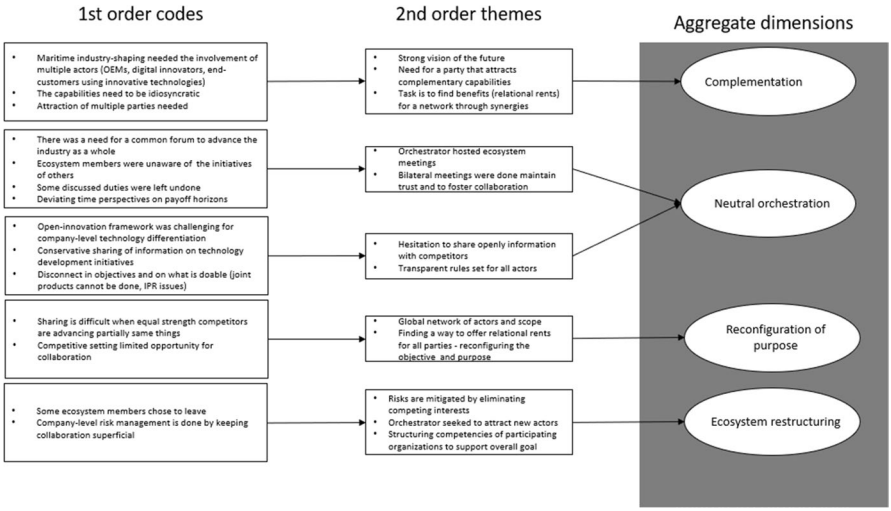


Fig. 4 The data structure as per Gioia et al. (2013)

finally reconfiguring its focus. Currently, the ecosystem continues with a greatly different objective and composition than it initially started with – the focus was ultimately reconfigured from open and joint innovation work to legislative influence.

In this section, we discuss the factors behind the ecosystem's evolution through *centripetal* and *centrifugal forces* (Holgersson et al. 2022), *sources of imbalances* (Choi and Wu 2009), and *sources of relational rents* (Dyer and Singh 1998). We then make an interpretation how the ecosystem was solving the states of unbalances to generalize the findings. Table 4 provides a structured storyline of the ecosystem's evolution and a visualization of each stage of development. The table details the forces (column 1), sources of imbalances (column 2), sources of relational rents (column 3), and acts to maintain the balance through *alignment mechanisms* (column 4). The last column illustrates the evolution with a visual graph.

5.2 Dynamics at the emerging phase

Before the ecosystem was established in 2016, there had been a themed discussion on the digital transformation of the maritime transportation industry and the future of autonomous maritime shipping among some of the major industrialists. The key maritime technology companies shared a unified view that digitalization could significantly advance both the safety and sustainability of the industry. The initial idea was to promote *Autonomous Maritime Fleet* operations – how goods could move in unmanned ships. At the time being, such vision was a radically innovative idea, but for which no formal collaboration forum was available to advance the course.

At the time, company A had already developed their own technology roadmaps towards the vision of unmanned ships, but it had realized that the emergence of the smart shipping industry would need active collaboration between other leading industrialists as well as contributions of much smaller niche players, mainly digital innovators. These smaller companies possessed distinguished capabilities, such as ICT communications and AI and analytics-related competences that complemented the solutions of the key industrialists. Company A said that:

> *"…we didn't think that it was possible to have all capabilities in one company, no matter how big the company is. So, that's why we decided on this approach to build this [vision] together, and together we can have a bigger influence. We knew that we couldn't influence the market on our own."*

During that time, the overall industry's development had relied on corporate-level initiatives of the major industrialists in head-to-head competition. Company A decided to take an unconventional approach by gathering the leading maritime actors as the materialization of the vision would need the development and implementation of parallel technology initiatives and additional digital capabilities. The leading company started to prepare a plan how the industry can be advanced. The discussions on the plan were held on the level of the major industrial players as they had formal and established relationships from their ongoing buyer–supplier connections.

Table 4 Dynamics of ecosystem over its evolution (centripetal/centrifugal forces, imbalances, relational rents, alignment mechanisms)

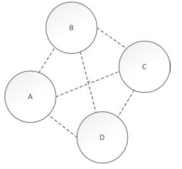
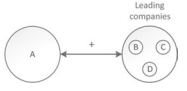
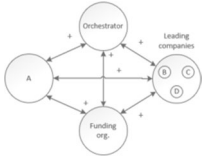
Centripetal/ Centrifugal force	Sources of imbalances	Sources of relational rents	Alignment mechanism	Ecosystem evolution	
(Centripetal) Theme discussions of maritime sector digital transformation	No collective forum to advance the topic among large industrial players exists Maritime sector digitalization needs a solid business case for end-customers (ship operators and industrial companies)	A collective forum would help to accelerate the digital transformation and industry renewal towards more sustainable and safe maritime transport operations	Put forward the idea of an association, an entity, or an *ecosystem* Building a business case for autonomous maritime industry as a whole		Emerging
(Centripetal) A strong vision of one leading company of the maritime sector ("keystone player vision")	Current technology development activities taken parallelly in standalone companies with strong product-orientation	Inter-organizational collaboration would enable benefits to be shared for all through overall market growth, synergy effect	Gathering complementary providers across sectors among leading industrial companies (technology providers, complementary digital innovators, end-users) ("complementation")		
(Centripetal) Industry-emergence is too ambitious task for one company to achieve	Large global organizations cannot lead one another (perception)	Ecosystem formation with the argument of involving leading players	Search for a maritime-related knowledge to coordinate tasks		
	Unclarities in what is an ecosystem, and how to work in an ecosystem	Embracement of market-shaping strategy	Establishment of a neutral third-party orchestrator		
			Search for risk-funding from the public funding organization		
			Expansions of the network from local to global scale		
			Tasks and duties of the ecosystem to be done jointly		

Table 4 (continued)

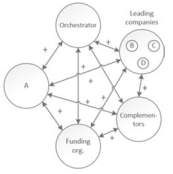
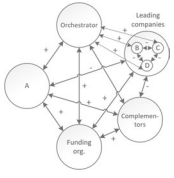
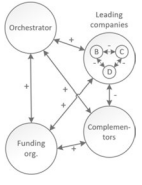
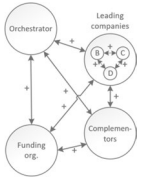
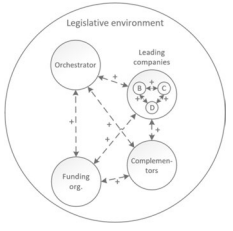
Centripetal/ Centrifugal force	Sources of imbalances	Sources of relational rents	Alignment mechanism	Ecosystem evolution	
(Centrifugal) Companies focused on their own activities	Challenges in open sharing of knowledge and information Duties of the ecosystem left undone	Benefits for all in sharing knowledge and having open discussions	Definition of principles for openness and equality		Development
	Time management among participating member organizations				
(Centrifugal) Diverging views on the outcome/ vision—the ecosystem should be either business- or innovation-oriented	Different perceived pathways towards the vision Different types of companies had varying expectations on the payoff horizon (e.g., corporate vs. startup)	Advancing the discussions in open manner via the orchestrator	Bilateral meetings and discussion with the orchestrator		
	Slow progress towards the vision		Keeping neutrality, openness and confidentiality		
(Centrifugal) A leading player withdrew the intention to do joint product development	Dispersion of interests	Less network value for ecosystem members	Search of new sources of value for the ecosystem shared by remaining members		
	Value of own development projects is prioritized higher than the ecosystem activities and ecosystem projects		Reconfiguring the ecosystem purpose		

Table 4 (continued)

Centripetal/ Centrifugal force	Sources of imbalances	Sources of relational rents	Alignment mechanism	Ecosystem evolution	
(Centrifugal) Competition law is notoriously difficult to interpret	Strict competitive setting of large global organizations in the sector impairs joint technology development	Realization that the ecosystem is a discussion forum to advance the industry emergence in a precompetitive setting	A strong vision of the new board that legislation needs to be changed first at a precompetitive phase to enable industry emergence		
	Technology differentiation is challenging in co-opetitive setting		Decision for fundamental change in focus from research and innovation (R&I) to legislation influence		
	Global organizations' due diligence wasn't aligned with open innovation in the ecosystem				
	Sharing only publicly available information				
(Centripetal) Sharing of costs and having an impact on the industry renewal at a pre-competitive regulatory phase	Perceived value from the ecosystem dependent on the ecosystem's focus and scope of actors	Opportunity for shaping the legislative environment for each own interest favorably	Ecosystem continues the legislation influence work by acquiring new members willing to invest in it and participate in legislation-related work		Renewal
	High participation fees and too distant time horizon for payoffs caused some customers to leave the ecosystem				
(Centrifugal) Emergence of niche ecosystems and projects with differentiated technology areas	Goal incongruence for the lack of technology development focus	Attracting new set of organizations for joint product and innovation development into new niche ecosystems	Design of new ecosystem(s) in line with the product and innovation development focus for differentiated technology areas		

The potential benefits were derived from the fact that by working together the creation of entirely new markets would be possible. In 2016 more concrete discussions were started at the level of the leading industrialists and the collaboration was officially labeled as "an ecosystem" with the aim to bring together companies across various sectors, motives for all participating actors (relational rents). The ecosystem was supposed to gather complementing parties from various sectors (technology providers, complementary digital innovators, end-users), that would motivate for joint research and development work for advancing autonomous maritime transportation industry. However, some of the companies were not so eager to the proposal of joining formally in the ecosystem—the collaboration model was felt radically different way of working than the companies were accustomated with. Moreover, the picture wasn't fully clear what would it have required from the companies when working in an ecosystem. Some of the companies agreed to join simply by virtue that their competitors were joining as well:

"…our competitors are there - we need to be there as well and then let's look what comes out of it. It doesn't cost that much - so we don't lose much participating… For some, the motivation was that it will be our way as that will be our future business…for the others, motivation was the so-called fear of missing out."
"…for anyone who wants to be considered as a serious player of the industry and has its own stake at the game, we understood that we have to be active in the discussions, and of course like everyone understands, the ecosystem was our best channel to be influential."
"…if you join your forces, the common [market] will be much wider."
"I believe that from every organization point of view there has been that sort of like a cost - benefit analysis or analysis of pros and cons of collaboration and everyone has to understand that together we are stronger."

At this point of time, the primary concern was that if partially competing organizations would collaborate towards the same objective, it would feel problematic from competition law viewpoint. The companies were not able to coordinate their activities well with each other, and no organization was acting as a broker to mediate discussions, especially on the difficult competing topics. The interviewees characterized the phase as follows, and highlighted some of the issues:

"*In the beginning it was, I would say, very unclear, or it was very fluffy on what to do, which probably was intended, and not a bad thing as such, because it forced us to talk to each other and then figure out what to do, get to know each other."*
"…How are you going to develop [autonomous systems] with your competitor developing those same solutions, [but now instead] in an open innovation framework, when you are looking to have some differentiation for your own solutions?
"…we were considering even joint ventures… a technology company that we would own [together] with the other large players. It is really OK from competitional law…. that is exactly what they do in the aerospace indus-

tries. A lot of these investments are so expensive that they rather do it with competitors. So, it is possible."

Since there was no party taking a role of a mediator, there was a source of structural unbalance among the actors – it was no-one's responsibility to find and settle for compromises. Furthermore, the activities of the independent organizations were not entirely synchronized, as there were no agreed ways how the ecosystem will target to meet its goals. A decision to establish a neutral third-party orchestrator was made to coordinate and align the companies' activities within the ecosystem, and to reinforce the motive for being part of an ecosystem. For example, one of the interviewees told us that:

"…of course, the big OEMS they're always competing – always creating better products. And always wanting to launch as a first. It's a continuous competition. We didn't believe that we could even change that. [But] we said that in some of the products or on some of those technologies we can act together. For example, the Navigation algorithms [of the future] should be open anyways."

The leading organization had set criteria for the orchestrator that it would need to have the required credibility to perform well in the task, and preferably have a deep knowledge in maritime sector. This directed the staff competences in the orchestrator organization. The role was perceived highly important, as noted:

"…a support function for a group like us at the time was essential. Without that, I don't think that we would have continued to meet either for a year."
"[The question was] who leads this kind of an effort because [we] felt that no single company can do it. [The others] are commercial companies. If [one] company leads another company, we may say that this is too much branded towards one company."

During the formation phase, public innovation policy was also heavily interested in offering seed funding for growth ecosystems, where the idea was to create spillover effects to the overall economy through the sector-spanning collaboration. The ecosystem chose to apply for funding for its endeavor, and successfully gained a positive funding decision. The sought funding was working as a "glue" among the participants as the public funding required renewing the business plans for the ecosystem, according to an interviewee. This was a phase of enthusiastic feeling for all the ecosystem participants, and the ecosystem was expanding its membership to global scale.

Then, the ecosystem faced publicity and criticism. For example, labor unions were skeptical if unmanned operations were ever possible and characterized that it would be "potentially illegal". Some other critiques further stated that it would be "unprofitable" and "too challenging task to handle". The orchestrator and the participating companies nevertheless believed that the future of the industry is shaped by collaboration, and despite the critique, the ecosystem members were rather confident:

"…we have already seen unmanned excavators in tunnels and mines, and wherever, and we have seen fleets of unmanned drones and other flying objects of whatever. So, this [vision] will be possible and it can be done."
"…Anyway, that sort of applying for funding - that meant also that we had to a bit renew our focus. So we weren't that idealistic anymore. We went more for, I would say a more concrete thing, that we would want it to make business for the companies and actually focus on getting concrete business and focus on getting funding for research projects and that sort of stuff."

Overall, the key issue for the *emerging phase* was to attract the right complementarities for the ecosystem. It required active engagement of the leading company with visionary idea on the possible complementors for concretizing the ecosystem. As Teece (2007, p.1321) discussed it, for gaining a sustainable competitive advantage, it is important to "shape the environment".

We find that in the context of ecosystems, understanding the suitability of potential partners, mutual interests and routines how to attract them is part of shaping the environment (Linde et al. 2021). From the leading actors' perspective, sensing of the environment included search of potential complementors and seizing the opportunity to attract them to the ecosystem were important steps (Teece 2007). Company A showcased this capability, and it was able to effectively communicate to the other leading industrialists. We find that the collective realization that the emergence of an entirely new industry needs active collaboration of some of the largest players in the field was a strong centripetal force, as the potentially new business opportunities were advantageous through the emergence of an entirely new market. We coin the term *complementation* as an alignment mechanism in the emerging phase of ecosystems.

5.3 Dynamics at the development phase

Despite the enthusiastic feeling among the ecosystem members, the companies were mainly focused on their own work and their own strategies; they were struggling with collaboration. This was a centrifugal force that was pulling the actors apart from each other, as there was imbalance in the expectations of the activities and outcome. The source of imbalance was a lack of well-aligned view of what were the means for meeting the vision. In addition, some actors had issues with time management in contributing to the ecosystems' work. As it was stated in an interview:

"*…the discussion started to have many kinds of variations".*
"…the two big players didn't want to do anything together. There was no sense of urgency to do anything together – it was more that OEMs were there to discuss together and then the development was done at their own isolation."

This situation required an agreement on common principles of sharing and equality, which were intended to serve all the members. The benefits of the joint work in an open environment were considered as a relational rent for all the members:

"…it was decided that the discussion in the ecosystem would always be open, but we would of course … not to breach the competition law, but it would be an open discussion as much as it could be. And there would be a lot of information sharing."

However, the views were still divergent, especially if the work should be manifested as business-oriented ecosystem with a clear business-oriented vision, or as an innovation-oriented ecosystem with the main idea of joint research and technology development in the long time-horizon.

"…we said there has to be a focus area, there has to be measurable target, and there has to be a deadline. That's something that we discussed and agreed with all the participants."
"…if you build an ecosystem, where the targets of the ecosystem are not shared by all the participants that you invite in, it is doomed to fail."
"…It was quite a lot of expectations of joint research and joint products."
"…in the beginning perhaps the roles of the ecosystem and expectations towards the ecosystem were a bit more varied … several work streams focusing on technical standardization or harmonization of the technical interoperability of the solution."

This diversity of views caused differently perceived pathways towards either a business or an innovation ecosystem. Thus, the joint endeavor was progressing slowly. Again, the state of unbalance had to be resolved in order to continue. At this point of time, the role of the orchestrator was especially critical, as it was able to mediate the discussions as a neutral party. The orchestrator had an opportunity to discuss issues at bilateral meetings directly with the companies and overcome some of the conflicting points, especially issues in collaboration of the largest industrialists, as their competing interests compromised their trust to one another.

"…if you think of the definition of a precompetitive collaboration, you know it starts to be competitive when you actually start to really form that business."
"…My challenge with the ecosystem was that it stopped the product development and now it's purely regulatory activity. And of course, it was why the ecosystem started at first place – it was doing joint research and development (R&D). That has changed a lot."

The neutral orchestration was a coping mechanism for the challenging phase by keeping neutrality, openness, and confidentiality for the players. The discussions advanced, until a remarkable action happened. An external company acquired one of the leading participating OEMs. The acquisition dramatically improved the leading company's capabilities for digital technology development of autonomous shipping, which potentially had influence on the stances how the ecosystems' actors then saw their role in the ecosystem during the period. However, after the company that acquired another leading player, it chose to withdraw all its intentions to do joint product development. The interviewees characterized this event as follows:

"…what happened after the M&A (mergers and acquisitions) deal… the key companies that were within were heavily disappointed."
"…the ecosystem was on the verge of falling apart, because, the parties who were into it, couldn't see much value in it anymore… what you had was kind of an alliance without the lead of the alliance.…when that one party was withdrawn, then the whole thing almost collapsed…"

This event became a strong centrifugal force for the ecosystem, as the initially leading company had much power and influence in the ecosystem. After this event, the dispersion of interests in the ecosystem appeared stronger. In fact, the value of the ecosystem joint work was perceived less valuable for some members than their own development projects. It was pointed out that:

"The large corporations decided that they will be working in the corporations' own networks or in some bilateral relationships."

This meant that the network value of the ecosystem was perceived weak, and the subjective relational rents in investing in the network's activities decreased from the initial. The ecosystem had to find ways to reconfigure itself and its purpose, and it had to find new sources of value serving the remaining actors in order to continue. The alternative and likely the worst option, was to dissolve the ecosystem and to lose the invested relational capital.

During that time, the competition law emerged to the discussions again, representing a powerful centrifugal force. Even with a shared goal to enable the emergence of intelligent shipping industry, the companies found strategic technology differentiation choices particularly challenging. Competition law didn't allow the companies to keep the discussions entirely open—or at least especially the largest companies perceived so. Internal tensions started to pile up as the views deviated how the idea of autonomous vessel operations and related technology development will be created—as a collective effort or in a pre-competitive phase. Moreover, the global organizations had their own due diligence processes that were not well aligned with the open innovation paradigm. Thus, the discussion in the ecosystem continued only on the level of publicly available information without revealing company-specific development projects. In the interviews, it was discussed that:

"…we were in the same seminars, but then all what we did was outside the ecosystem."
"*After a few rounds it was quite clear that joint products cannot be done within the [collaboration] platform as such… And the discussions and the risks with intellectual property rights (IPR) made it nearly impossible to even open up that discussion."*

To summarize, at this development stage, the role of an orchestrator was especially critical. Retaining the alignment with fair value appropriation, right incentives without a hierarchy is a challenging task for an orchestrator (Jacobides et al. 2018) and the orchestration sometimes happens to be a reason for ecosystem failure (Cui et al. 2022). In our case, we observed the benefits of a neutral status of the orchestrator. We thus propose that *neutral orchestration* can be a mechanism to retain balance

of forces. The neutral party was able to offer a mediating space and maintain trust among the ecosystem actors, especially at the face of diverging views of the key industrialists. Furthermore, the role of the orchestrator was to break barriers towards more open discussions and sharing. The neutral orchestrator was in the position to form an overall picture of the ecosystem's members and to start discussions how to continue the work.

5.4 Dynamics at the renewal phase

The state of imbalance among the actors reached its maximum before the renewal phase, where the ecosystem chose to pivot the initial focus. The phase was critical, as the ecosystem was close to falling apart due to the diverging views. There was a collective realization that strictly positioning into a pre-competitive setting, it is impossible to continue with joint technology development focus. The alternative pathway was that the ecosystem would no longer focus on joint technology development, but rather find a settling solution for all. According to one of the interviewees, at that time *"legislation was too big elephant to be eaten"*. The decision was agreed to be a new ecosystem goal and a vision towards shaping the regulatory environment for the autonomous shipping. The major shift was to become a guardianship organization "from innovation-focused ecosystem". Interviewees characterized the shift as:

> *"…it was discussed that how do we refocus the whole activity for all these parties so that it truly adds value for all the parties. And then it was decided to be reframed that this alliance is about creating or advising on how we need to create the regulatory framework…"*
> *"…in order for some of the companies, and especially largest companies to want to continue, we needed to have a very clear direction. When we had made that decision [towards legislative influence] we started to work towards the activities that would satisfy the strategic needs of [all] the participant companies."*
> *"…we went from being really idealistic to more realistic considerations."*
> *"…we were much more mature also in our thinking … and had better understanding that how the industry actually will evolve… and it's more like an evolution than revolution… it is a continuous development rather than anything that would happen just overnight."*

This decision was two-fold. On the one hand, it allowed to build a very open collaboration, discussion, and trust at the pre-competitive setting among the remaining companies, avoiding the collaboration at competing areas of interests. This decision reinforced the motive for being part of the network, and generated relational rents for the leading companies. Interviewees said:

> *"…the level of concreteness in the discussion has increased a lot …there has been also building of trust among the members because everyone has been contributing really a lot… [It allowed] opening points of view, that there has*

suddenly [born] some sort of like ecosystem ideology about how we wanted things to proceed".
"Now, perhaps the discussion around the regulation is neutral enough environment and it looks like that we all are quite aligned there."
"…If the legislation and the regulation prevent us [ecosystem innovators] from implementing the new technologies new business models…there is no benefit of any of the technology and business development if couldn't implement them."

On the other hand, since the ecosystem surrendered the idea of joint technology development, many complementing companies of the ecosystem left because their interest was purely based on the idea of joint technology development.

The remaining leading industrial players were still interested in the ecosystem with the new legislative focus. Cost sharing and having an impact on the pre-competitive regulatory-shaping was a centripetal force opening up long-term opportunities. However, the case was challenging for smaller technology complementors and possible customers of the ecosystem, whose business interest were framed for a much shorter time horizon. It was simply not possible for them to continue with rather high membership fees and costs, and with too distant time horizon for the future outcome. The interviewees put it in this way:

"This was really mega point of change because it turned the discussions to two directions; ones who want it to have the legislation changed, and they wanted to put all the effort on that side, and the ones who were there in order to develop new technologies, create new research and development and innovation projects."
"One of the most challenging things is to create the ecosystem that all the different types of organizations would then get some of the monetary value considering their realities. So, the timespan for value creation is much varying … some of the members have left due to falling short in expectations."
"*…we had stakeholders participating as members, that then soon leaving after one or two years because the expectations were not met."*
"…they did not feel anymore that they were getting their money worth, so to say. One of the things that you need to know about the ecosystem is that there was a very high membership fee... It's a lot of money for a company to put in something where they might not get concrete results."

The ecosystem's structure had changed in a way that some complementary technology innovators chose to leave the ecosystem. The orchestrator had to find a way to continue towards the legislation influence. The orchestrator had also to pivot its focus to acquire new ecosystem members serving the new goal. Although the opportunity to participate in regulatory shaping was perceived advantageous for the remaining actors, in the renewal phase, the mechanisms to reach an alignment was in *ecosystem reconfiguration* and *restructuring* of the ecosystem. Reconfiguration was done by establishing clearly a pre-competitive setting and a vision towards shaping the regulatory environment. It was a strategic decision to overcome the point of dispersion at the previous phase. The act of reconfiguration is in line with the dynamic

capabilities by Teece (2007) and Linde et al. (2021), suggesting that calibrating the activities are needed to maintain evolutionary fitness. The reconfiguration had to be done in parallel with *restructuring* of the ecosystem, as the composition of the ecosystem wasn't supporting the new vision mainly because of misalignment of actors' expectations and the actual outcome horizon of the ecosystem.

Overall, reconfiguration of the ecosystem allowed to differentiate the work that had to be done for the industry renewal. The evolution then allowed niche ecosystems and projects to emerge beyond the case ecosystem, with clearly differentiated technology focus areas, for example, port operations. As one of the interviewees emphasized:

> *"Some of the partners who left the ecosystem, they are still willing to collaborate with all the members, but in other aspects than the focus of the ecosystem. That's why they are not members, but they create individual research and development projects for certain technology and business things, and they carry those out outside the ecosystem.*"

6 Discussion and conclusions

This research was carried out to explore how balance in interorganizational dynamics in ecosystems can be maintained. By adopting an in-depth single case study method with a retrospective, the paper analyzed the evolution pathway of an autonomous transportation ecosystem in the maritime sector. The researchers qualitatively collected views of the ecosystem actors over its evolution, and evidence was found how orchestrators retain balance in ecosystems' interorganizational dynamics.

Our study elaborates on existing theories—the balance theory (Anderson 1979), centripetal and centrifugal forces of ecosystem' evolution (Holgersson et al. 2022) and relational rents (Dyer and Singh 1998). In particular, the paper offers elaboration to these theories in the context of ecosystems. We contribute to the management research "backlog" in the context of Industry 4.0., from the perspective of cooperation and networks, and change leadership (Schneider 2018). Moreover, the results have practical implications for potential orchestrators of ecosystems in terms of understanding the role of alignment mechanisms in reaching a balance in interorganizational dynamics, and for policymakers in understanding the role of ecosystem's design in the attempts to address global systemic challenges. We also contribute to dynamic behavioral relationship analyses based on social network studies, which is particularly relevant for practitioners thriving to build competitive advantage with networked collaboration in ecosystems. In this section, the key theoretical and practical implications are outlined, and future research opportunities and limitations and are discussed.

6.1 Theoretical implications

First, the results of the study provide theoretical implication to the evolutionary perspective of ecosystems' development and their lifecycle (Klimas and Czakon 2022).

While the research on ecosystem's lifecycle agreed on certain development stages, such as emergence (or initiation, or launch), expansion (or momentum), maturity (or establishment), and dissolution or renewal (or death) (Moore 1996; Autio 2021; Letaifa 2014; Thomas et al. 2022), these conceptualizations are commonly linear. The paper's findings elaborate on this discussion—we witnessed a non-linear evolution process in the analyzed case. We conclude that ecosystems' evolution involves intermediary successes and failures—in line with the initial natural analogy of Moore (1999), in which Moore highlights the importance of understanding power dynamics in social systems. We argue that the specific alignment practices of orchestrators can potentially help in overcoming the emergent and contextual challenges in the interorganizational collaboration.

Second, we find that unclearly set value proposition or unclear means for achieving the ecosystem objective (e.g., innovation work vs. business orientation) cause imbalances in the interorganizational dynamics. The imbalances, we theorize, arise due to changes in relational rents. Relational rents can be used to explain how each party extracts value from the network based on their subjective view of the transaction costs and associated value of belonging that network. We conclude that the role of ecosystem orchestrators is to foster the generation of relational rents for all parties by acting as a broker in mediating collaboration, trust, transparency, information, and risk-sharing. In other words, to restore a balanced state under the lack of relation rents, there is a need for orchestrators to develop contingency-dependent coping mechanisms, which, in turn, drive the evolution of ecosystems. We call these *alignment mechanisms.*

Third, we contribute to centripetal and centrifugal forces driving ecosystems' emergence and evolution (Holgersson et al. 2022). Our analysis suggests that centrifugal forces bring significant risk of dispersion of actors' interests and intentions. We conclude that the sources of centrifugal forces mostly emerged from the head-to-head competition faced by some of the global industrialists. Even though co-opetitive objectives had benefits for the companies, such as potential generation of an entirely new market, untapping new sources of customer value, potential resource for synergy, and improved competitive positioning against other rivals, creating a truly collaborative environment is indeed difficult. The tough competitive setting among the leading industrialists of the ecosystem led to lower levels of sharing and lack of transparency of the intentions. The role of orchestrators is to mediate the discussions and to find a balance.

Fourth, the study provides a theoretical implication to the commonly acknowledged roles in ecosystems. In line with the previous studies (e.g. Iansiti and Levien (2004), Jacobides et al. (2018), we identified the crucial and powerful role of the *lead companies* or the *keystone players*. Our findings show that a significant influence of multiple leading companies can be an equal case aside to one leading actor. In our case, they were all active major industrialists at the emerging phase, although heavily inspired by the initial leading organization. We thus conclude that the shared leadership could have been the case of this ecosystem (Adner 2017), and we add to the discussion on the roles of ecosystems (e.g. Iansiti and Levien 2004; Jacobides et al. 2018) to highlight the simultaneous influence of multiple complementors. We thereby propose a role of *"leading complementors"* or *"key complementors"*

in ecosystems to indicate that there may exist multiple highly influential parties. In our case, we witnessed that complementarity of all actors was a vital glue for ecosystem alignment (Adner 2017), yet, we observed a strong power of the leading industrial players who were crucial for complementing the ecosystem's overall value proposition.

Fifth, the results of the study provide a theoretical implication to the alignment structure of ecosystems (Adner 2017). We propose that alignment mechanisms aim to shift the structures, objectives, and composition of an ecosystem to solve the imbalances and make the actors not only participate but also to align with the ecosystem. We propose four alignment mechanisms:

Complementation (1) as a mechanism to attract and gather complementors to the ecosystem and create a strong network of industrial players towards a specific goal. This alignment mechanism is in line with dynamic capabilities (Teece 2007; Helfat and Raubitschek 2018; Linde et al. 2021) and the idea to seize the opportunities by gaining the necessary complementors in the ecosystem.

Neutral orchestration (2) is a mechanism that allowed a third-party orchestrator to mediate activities and discussions between competitive actors. Neutral status of the orchestrator was especially important for our industrial context, as the competition exceeded beyond the ecosystem's scope. The important role of an ecosystem orchestrator was discussed in the previous literature (e.g. Kapoor 2018; Williamson and De Meyer 2012; Cui et al. 2022), however we propose a neutral orchestration mechanism to emphasize the significance of neutrality of an orchestrator in competitive industrial context.

Then, *ecosystem reconfiguration (3)* is another alignment mechanism that encompasses strategic changes in the ecosystem. It is a part of the dynamic capabilities by Teece (2007), which suggests calibration of activities to maintain evolutionary fitness. In the case ecosystem, we identified a refocus of the ecosystem's goal as a mechanism to align the remaining actors at the critical point of actor dispersion.

Finally, *restructuring (4)* is a mechanism to align the ecosystem vision among all the interested actors. This mechanism allows to remain the agreement on the ecosystem goal, bring new members to the ecosystem and allow unfitting members to leave the ecosystem.

Overall, the ecosystem approach which was initiated by the leading company at the emergence phase is the evidence of a dynamic capability. The leading company was sensing the future opportunities and actively participated in the industry discussions regarding the emergence of autonomous maritime shipping industry. It was able to sense the opportunity for shaping the future maritime industry. This shows a vivid example of dynamic capabilities of a firm to complement its own capabilities (Teece 2007), which in the end led to the emergence and development of an ecosystem.

6.2 Practical implications

The paper's practical contribution is application of the suggested four alignment mechanisms in resolving unbalances in ecosystems' dynamics in order to create

competitive advantage and value for all ecosystem members. These mechanisms direct ecosystems' work towards their next evolutionary phase(s). First, with *complementation*, we refer to the activity, in which complementary skills of distinct organizations are being identified and attracted towards a shared objective, in which the activities are attributed to the party that carries the required competencies. This allows realization of novel business strategies, for example *industry-shaping* as a network. We find that a trigger for ecosystems' emergence can simply be a visionary outlook of the future. However, if a firm aspires to shape the course of an entire industry, an ecosystem can well be a foundation for the work but gathering various capabilities that bridge current missing links in an industry is key. This needs an in-depth understanding on the opportunities and limitations that new technologies can bring as well as understanding on the strategic goals of other ecosystem members.

Second, with *neutral orchestration* we mean that as ecosystems are "living organisms of the business world," their internal dynamics must be solved in a manner that satisfies the needs of each independent ecosystem member. A mediating or brokering role is vital in the process, especially if the network involves any dynamics of head-to-head competition.

Third, *reconfiguration* means that the focus and goals of the ecosystem can be changed to align the ecosystem's work with the objectives and strategies of all its members. In practice, this refers to a reborn of an ecosystem to a new appropriate strategic goal embraced by every ecosystem member. The reconfiguration can, however, lead to dissatisfaction, and abandonment by its original members.

Fourth, *restructuring* means that if any objectives and goals are changed, the ecosystem-level competencies might need to be readjusted to better serve the overall purpose of the entire network. If the key capabilities are scarce, the ability to generate the ecosystem-level offering is also resource dependent. It is also noteworthy to mention that the needs and time horizon for the involved parties might be different, which calls for different adjusting tactics depending on the sizes of the participating organizations. As the case ecosystem incurred a membership fee, adjusting the membership schema more favorable for niche innovators, that typically were start-ups, might have served as a tool that would have helped to retain some actors.

Fifth, we conclude that the initial design of the ecosystem, its structure, alignment mechanisms, and expectation management are vital for ecosystems' smooth operations. The lesson learned from the case ecosystem's evolution process is that ecosystems experience consecutive successes and failures, which, in turn, are largely caused by the expectations for the outcome through the initial alignment structure. From orchestrators' viewpoint, by defining the ecosystem architecture (including roles and expected contributions), the potential destructive dynamics could be anticipated before they emerge.

Lastly, our findings suggest guidance for innovation policymakers. We find evidence that policy support for ecosystems has been essential for advancing and renewing entire industries in an innovative way. As our case study reveals, the aspiration to change the entire maritime shipping industry to more efficient and sustainable with the help of digitalization was much broader than any of the ecosystem members' core capabilities. This clearly fell to a grey area, which no established business could have managed alone, or it would be too risky.

Therefore, we conclude that policy support for advancing technology development in ecosystems can accelerate the process of renewing industries and help to "increase the size of the pie" for all. However, we note that for an ecosystem to succeed, policymakers should emphasize the importance of initial design as part of their funding criteria. We find that if the ecosystem architecture is merely based on a common vision, it is potentially challenging to maintain balance in the actor alignment. Consequently, if the commitment to the ecosystem's work is hampered by deviating expectations, it risks meeting the objectives for given subsidies by abandonment of parties. Lastly, we note that as competition law is notoriously difficult to interpret, more specified law guidelines for ecosystems' work would be beneficial. This is a particular concern of sustainability-oriented ecosystems that aspire to address grand challenges of our times in a pressurized schedule.

6.3 Limitations and avenues for future research

Our paper has few important limitations to consider. As a single case study, the results of this research are not entirely generalizable. Rather, the paper offers guiding evidence on how alignment and balance in ecosystems' dynamics can be maintained. We collected the primary data from the six key representative organizations of the case ecosystem; the list however did not cover the entire composition of all past and present ecosystem members. The missing companies, although more niche ones, could have offered additional perspectives to the dynamics. Nevertheless, we conclude that the interviews from the core ecosystem contributors provide a saturated data for an accurate and profound analysis of the evolution due to their more intense involvement in the process. We further acknowledge that these views are a retrospective interpretation of the dynamics, and, therefore, also subject to bias. To increase the validity of our findings in-depth studies would need to be done in greater numbers. Considerations of longitudinal case studies on the development and evolution of ecosystems would also be highly valuable. However, this study represents an emerging research direction to advance understanding on maintaining interorganizational balance in ecosystem dynamics. We suggest that observing the changes in balance in the interorganizational dynamics can be done with the help of our framework (Fig. 1). Also, a comparative case study method would be another avenue for detailing the context under which the alignment mechanisms are effective.

We further recognize that qualitative research methods include a risk of subjective bias due to judgmental nature of researchers (Galdas 2017) – yet these risks were minimized by coherently following case research protocols and methodology of concurrent collection and analysis of the data, and, by theoretical back-and-forth linking from data to theory and vice versa (Morse et al. 2002). Finally, the research process was executed by two researchers whereby the data analysis was done in parallel and regularly discussed to eliminate alternative interpretations and biases.

Appendix 1 Interview objectives, questions, and guide

Objectives of the interview(s)
To gain understanding on ecosystems
How are ecosystems conceptualized across organizations?
How different organizations participate in ecosystems?
To gain insight on the evolution of ecosystems
By discovering the major ecosystem events
By discovering what kind of dynamics there has been over the ecosystem's life?
By discovering how the ecosystem dynamics influence on the events?

Questions

General questions
1. Explain your role (job-role, function) within your company and in the ecosystem
2. Describe what an ecosystem is, according to your own words?
Understanding the case ecosystem, evolution, and dynamics
3. Describe the case ecosystem in your own words
4. What was your organization's role in the case ecosystem? Why did your organization participate in the case ecosystem?
5. Describe the story of the ecosystem from its initiation till now
6. Elaborate on the ecosystem's vision, goals, and objectives
7. How did your organization get involved in the ecosystem?
8. What key events would you identify in the ecosystem evolution?
9. How did the key events affect the development of the ecosystem?
10. How would you characterize the dynamics in the ecosystem after a particular event (event X, Y, Z)
Dimensions of ecosystem dynamics (Alam et al. 2022a***)***
1. Trust – how would you characterize the trust among ecosystem members after event X, Y, Z?
2. Collaboration – how would you describe the collaboration after event X, Y, Z?
3. Sharing – how would you describe sharing of assets and capabilities after event X, Y, Z?
4. Transparency – how would you characterize transparency after event X, Y, Z?
5. Risk-sharing/taking – how would you characterize the risk taking after event X, Y, Z?
11. In the future, do you anticipate any significant events that would be influential for ecosystem's evolution and the dynamics of the ecosystem?

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Data availability The dataset analyzed during the current study is not publicly available due to confidential company data.

Declarations

Conflict of interest The authors declare no conflicts of interest.

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