Unlocking Value Creation by Embedding Investments in Business Ecosystems: Implications for System Governance[1]

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Abstract

Investments in large projects in infrastructure, logistics, construction or energy often fail to generate their intended value. There is a need to develop alternative models for analyzing large project investments where their ability to deliver maximum value for users and stakeholders is the main success criterion for their *functionality*. Maximizing stakeholder value across the business ecosystem will often require purposefully reconfiguring the way ecosystem actors collectively create value across industry sectors and over time. This requires coordinating workflows among the actors involved in delivering and operating the investment over its lifecycle, as well as with actors outside of it. In this paper, we propose a framework that considers both the lifecycle of an investment and its embeddedness in a larger business ecosystem in order to design enhanced governance mechanisms that can optimize system-level value creation. The framework utilizes systems and network research. It elaborates James Thompson's notion of "reciprocal interdependency" into two distinct types of interdependency between supply chain participants—"compatible" vs. "contentious" interdependency—that require different types of governance to manage them. It provides a model for the structural analysis of workflow interdependencies between different phases of the investment lifecycle and

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between different parts of the business ecosystem. The analysis of a vessel investment within a short sea logistics ecosystem illustrates how the proposed framework can be applied.

Keywords: contentious interdependency, compatible interdependency, virtual hierarchy, business ecosystem, system value creation

1. Introduction

Observers have frequently questioned whether investments in large projects in infrastructure, logistics, construction or energy generate the value they were intended to generate (Flyvbjerg *et al.* 2002). There is a need to develop alternative models for the analysis of these kinds of large project investments (Walker and Lloyd-Walker 2015), where their *functionality*, i.e., their ability to deliver value for users and stakeholders, is seen as the main success criterion. We propose that the functionality of investments can be better understood when they are studied as parts of a business ecosystem. Previously, business ecosystems have been defined as evolving communities that consist of interacting organizations producing goods and services of value to customers (Moore 1996). In this paper, we draw specific attention to the notion of interaction and therefore define a business ecosystem as a network of interconnected workflows of several organizations that aim to deliver value to their customers (Moore 1993, 1996) or collectively respond to market needs (Dalziel 2007). The governance of workflows in a particular business ecosystem largely defines how much value a new investment will create for the sponsors, owners, end users, society and other stakeholders. Conflicting structures in a business ecosystem can diminish the intended technological, environmental, and financial benefits of such investments.

For example, the Baltic short sea logistics business ecosystem that we analyze in this paper can be defined as having the ultimate system goal of offering reliable, high-quality, and sustainable transportation of goods. The multitude of business actors involved in marine, port, and land logistics, as well as in shipbuilding, are part of a business ecosystem that needs, as a whole, to achieve this goal, generate value at the system level and capture value for the individual supply chain participants. However, as mature industry structures become settled through differentiation and specialization processes (Porter 1980, Hagel and Singer 1999), and increasingly constrained by explicit or implicit institutionalized system architectures, the industry logic and the way investments are delivered get locked in. This allows the value chain to achieve local efficiencies and subsystem technological enhancements, but the rigidity of the system architecture then creates a formidable barrier to systemic innovation (Sheffer 2011, Sheffer *et al.* 2013) and prevents ecosystem actors from responding collectively to evolving demands in an efficient manner. As we illustrate further, the challenge of delivering a vessel investment that creates high value and contributes to achieving the overall ecosystem goal derives from to the structure and governance of the current business ecosystem.

The general problem of entropy associated with "imperfect transmission" leads to the modification of rules and ways of working under the pressure of various circumstances (Scott 2008), which can result in business ecosystems that are not guided by the motivation for system efficiency. Companies, by developing their own business models and defining their way of collaborating with others, can make an industry highly transactional, leading to a Nash Equilibrium where there is little room for any party to deviate from commonly used practices, because unilateral deviation from the system architecture incurs high costs for that participant (Hagel and Singer 1999). This situation can only be improved through a system-wide institutional change in how business is done, and how value is created and distributed among the actors.

Business ecosystems are not the same as networks, because networks typically concern one kind of actor, such as biotech firms (Powell *et al.* 1996), or businesses (Håkansson *et al.* 2009). Business ecosystems involve actors of all kinds, as long as they influence the workflows and system value creation (Mäkinen and Dedehayir 2012). Another difference is that business ecosystems can be analyzed with the explicit purpose of improving the efficiency of the system (Santos and Eisenhardt 2009), whereas networks cannot. A similarity between network research and business ecosystem research is that both focus on how value is created through workflow interaction and coordination. We thus utilize both network research on workflow coordination (Zajac *et al.* 1993, Holm *et al.* 1996), and workflow interdependency theory (Thompson 1967) when we define a business ecosystem as a system of interdependent workflows. The analysis of workflow interdependencies is structural functional, since the nature of the workflow determines the need for coordination and interdependence.

The workflows depend not only on the nature of the work performed, but also on the actors involved, because their goals matter for the workflow coordination. The resources involved matter as well, because availability of resources also influences workflow coordination. Actors that influence the workflow are not only business actors, but also institutions, such as regulators. Resources that influence workflow are broadly defined as those required to operate the workflow, and may include input material, knowledge, or even legitimacy. When investments are made, their functionality is defined by how they are embedded in workflows, i.e., the overall business ecosystem, and their potential to create value through that embeddedness. Business ecosystems can frequently generate more value by improving workflow coordination at the overall business ecosystem level, but actors may have conflicting goals, and resources may be scarce, so that the full potential of the entire system for value creation is not realized.

Research on business ecosystems have found that they can change due to the introduction of new business models (Jacobides *et al.* 2006, Tsvetkova *et al.* 2014). Apart from that, there is little knowledge about business ecosystem governance. Research on systems governance finds that rules or institutions are developed in the system as it evolves, and that these rules can be created and maintained in a decentralized way by the actors in the system, with only limited central governance (Ostrom 1990). Such a view suggests that system governance should focus on using as little centralized governance as possible, and that governance should serve to give direction for overall business ecosystem improvement.

This paper proposes a framework for the analysis of business ecosystem governance from the perspective of individual and interconnected investments. We aim to determine the most appropriate governance mechanisms for an ecosystem based on the character of workflow interdependencies related to a particular investment. Thus, the boundaries of explored business ecosystems are defined based on which interconnected workflows greatly affect the functionality or dysfunctionality of the investment in focus.

2. Research approach

The research process behind this paper is based on a clinical inquiry. Clinical research originates from the research tradition of action research and implies engaging in solving problems that are relevant to the industry (Schein 1993, 1995, 2008, Schön 1995, Coghlan 2000, Coget 2009). In this mode of research, the researchers help companies to diagnose and solve problems. Thus, the main aims of a clinical inquiry include solving a clinical problem and triggering organizational change (Schein 1995). The main feature of such an approach is that tight cooperation with business actors occurs throughout the process and is iterative. This allows for better access to data and constant validation of research results with the practitioners (Coghlan 2011).

The framework proposed in this paper has been developed based on both conceptual and empirical work. The researchers are involved in an ongoing project that aims to analyze the short sea logistics business ecosystem in the Baltic Sea and, together with practitioners, develop solutions for increasing its efficiency and sustainability. The focal industry can be characterized as mature, traditional, and heavily institutionalized. It has faced tightening sulfur emission regulations that require the use of cleaner fuels and/or costly emission-abatement technologies. This has led to increased marine transportation costs and threatens the economic viability of the whole sector, and of organizations and nations that are highly dependent on short sea logistics, notably Finland. At the same time, there is great potential for improving the overall efficiency and sustainability of the focal short sea logistics ecosystem through changing the way different actors interact, utilize resources, and organize their activities. One specific challenge concerns the way vessels, being key investments in the ecosystem, are delivered and operated. This paper explores the potential for increasing efficiency of the overall business ecosystem by altering the way vessels' investments are governed, using a framework designed to analyze this illustrative case.

During the focal project, the challenges related to the current short sea logistics ecosystem and the way vessel investments are governed were identified through extensive discussions with actors representing different parts of the ecosystem: marine logistics, port logistics, and export industries are the main users of logistical services, shipbuilding, etc. After confronting the challenges thus discovered with theoretical insights regarding business ecosystems, network studies, and project management, we developed the initial conceptual framework (presented in section 4). We used this framework for in-depth analysis of the focal short sea logistics case, and refined it based on the findings of empirical analysis, as presented in section 6.

3. Literature overview

Due to globalization and increasing interaction in business, the value creation of a business is increasingly generated from systems of interconnected and interdependent workflows. As a result, organizational research increasingly intersects with systems research.

3.1 *Governance of business ecosystems*

Most research on organizational systems has emphasized individual value appropriation over system value creation (Järvi 2013). For instance, there is extensive research on business systems and system innovation that explains how industries are altered due to the actions of individual companies (Normann and Ramírez 1993, Gulati and Singh 1998, Echols and Tsai 2005, Sarasvathy and Dew 2005, Jacobides *et al.* 2006, Pisano and Teece 2007, Gulati *et al.* 2012). That is, the focus of exploring system "shaping" efforts revolves mostly around, for example, the way companies profit from system innovations by appropriating a larger share of total value creation (Teece 1986). Business ecosystems, defined as systems of interconnected workflows, thus contribute to organizational research by the development of an applicable analytical framework that takes a simultaneous systems and workflow perspective that is not confined to the value creation of individual companies.

Workflow interdependence is an integral part of value creation, as system-wide workflow coordination can unlock benefits of value-creating business organizations, such as complementarity in resources (Dyer and Singh 1998), supply chain efficiencies (Zajac *et al.* 1993), network externalities (Katz and Shapiro 1994), and relationship value creation (Holm *et al.* 1996). Efficient workflow interdependence is achieved by the appropriate coordination of interdependent workflow activities with different kinds of interdependency (Thompson 1967, Bailey *et al.* 2010). In business ecosystems, workflows are observed to connect across multiple actors, effectively forming networks of interdependence that transcend firm boundaries (Zott and Amit 2010). Some business ecosystem research does define business ecosystems as networks of interdependent firms (Mäkinen and Dedehayir 2012, Clarysse *et al.* 2014). However, workflows have traditionally been analyzed within the confines of a single organization, or a specific business relationship, but not previously at the level of the larger business ecosystem.

A common criticism of workflow analysis is that it represents an under-socialized view of organizations, since it pays more attention to the structural functional coordination of work tasks, than to social structures. While we focus our analysis of business ecosystems on workflow integration, we will employ network research as a way to analyze the business context of workflow interdependence. For instance, the ARA network analysis model identifies not only workflow or activity interdependencies, but also network resources exchanged, and actor relationships (Håkansson *et al.* 2009). This allows one to simultaneously address technological as well as social and economic interdependencies involved in certain workflows. The actor relationships can be relationships between corporate actors, government actors, civic society actors, or any other kind of collective social actors. The resources involved can be raw materials, knowledge, information, or any other resource used in production of a good or service, or can include the goods and services themselves. Adding resources and actors to our analysis of activity or workflow coordination allows us to analyze social structures that may influence the business ecosystem.

General systems research argues that the whole of the system is more than the sum of its parts (Simon 1996). Extending this to business ecosystems, the value produced in them can be enhanced by aligning the parts. Following from our earlier definition of business ecosystems as interdependent workflows, the alignment of the parts in the business ecosystem means that workflow interdependencies should be aligned, in order to increase the value of the entire business ecosystem. The alignment of workflows is not easily achieved, however, because actors may have conflicting interests, or resources may be scarce. With respect to value creation in the business ecosystem, it is of interest to govern the system in such a way that it supports workflow integration. For the individual actor in the business ecosystem, the self-interest may not be to increase efficiency in the business ecosystem. Governance of the business ecosystem therefore incorporates "market" organizing and "hierarchy" organizing at the same time. Business ecosystems may even be seen as neither markets, nor hierarchies, but simply as networks (Powell *et al.* 1996).

Governance of business ecosystems will probably be very different when the actors and resources are compatible than when they are contentious. We call the former compatible governance, and the latter contentious governance. Compatible governance is more a matter of connecting and organizing actors that need to share information continuously to maintain output compatibility, and to distribute information about module requirements and allocate system-level resources for work tasks to function well. Contentious governance requires more conflict resolution, since actors need to negotiate output and interface details with one another in the presence of goal conflict, and where resources are scarce. Because of these great differences, we will present the two approaches as dichotomous in the analysis of business ecosystems governance.

A successful example of contentious government occurred in the US semiconductor industry in the 1990s. When faced with falling market shares, a government intervention reorganized competing business actors to co- operate in research and development of next generation semiconductors (Browning *et al.* 1995). The government stepped in to govern market actors, and forced contentious actors to work together for the greater good.

3.2 *Workflow interdependencies and business ecosystem governance*

As the scale and scope of a product or service grows, there is a natural tendency for the tasks to be subdivided into smaller tasks, and for the workers who execute them to become increasingly specialized. From the earliest days of organization theory, it has been observed that this division of labor, with the resultant specialization, produces three kinds of outcomes: The expertise to perform particular subtasks becomes isolated to the local experts who perform them; each set of specialized workers develops its own terminology; and the specialized workers tend to develop local subcultures with their own parochial subgoals (Lawrence and Lorsch 1967, Heath and Staudenmayer 2000). This creates a need for either centralized or distributed coordination to achieve an integrated system-level outcome.

James Thompson (1967) defined three kinds of interdependence between tasks in the workflows of complex, fragmented tasks performed by specialized workers. Each requires a different coordination mechanism.

Pooled Interdependence

The simplest type of workflow involves “pooled” interdependence, in which workers accomplish a set of tasks, all of which are needed to achieve the desired system-level outcome, but there are no technical or timing interdependencies between tasks. Any task required for completion has at least pooled interdependence with other tasks in the project. The system integrator of a fragmented workflow can coordinate pooled interdependence among subtasks by specifying tasks’ required outputs and the skills required by the workers who will carry out those tasks. Alternatively, for unskilled workers, pooled interdependence can be coordinated by specifying –and in some cases, enforcing– the detailed work process by which each task should be carried out. Unless the scope of the required system changes, workers can then complete their tasks relatively independently of the system integrator or other workers, because there are no technical or timing interdependencies between tasks.

Pooled interdependence is the least costly form of interdependence to coordinate. Mature industries evolve highly institutionalized “system architectures” to define standard component functions and subsystem interfaces—e.g., IBM’s PC system architecture that they developed and published in the early 1980s, and that still dictates many of the subsystem functions and interfaces on modern desktop or laptop computers—but not on tablets.

The industries that deliver office buildings, PCs, and smartphones are examples of mature and fragmented industries. Thus, even “one-off” or innovative products—like new office buildings or successive versions of a MacBook Air™ laptop—can be delivered by a fragmented supply chain with the system integrator—the general contractor, in the case of an office building, or Apple in the case of the MacBook Air—using mostly these low-cost central coordination methods for addressing the predominantly pooled interdependence between subsystems.

Sequential Interdependence

If a given task that already has pooled interdependence with all other tasks in the project faces the additional constraint that it cannot be initiated until one or more prerequisite tasks have been partially or fully completed, the two or more involved tasks exhibit “sequential” interdependence as well as pooled interdependence. Sequential interdependence arises from physical, topological or shared resource constraints, so that the involved tasks need to be executed in a sequential manner—for example, in conventional manufacturing and assembly or construction.

A system integrator can coordinate sequential interdependence centrally by: (1) scheduling tasks to occur in a specified sequence and requiring them to be completed by specified times, and (2) rescheduling tasks as needed to accommodate variance in the completion of prerequisite tasks or shortfalls in the availability of required shared resources. Inserting buffers between tasks that have high variance in their durations is a commonly used strategy to avoid the need for frequent rescheduling (Goldratt 1997).

Reciprocal Interdependence

The third type of workflow defined by Thompson involves “reciprocal” interdependence between two or more subtasks. Thompson stated that coordination of this type of interdependence requires “mutual adjustment” between the interdependent parties, but did not clearly explain how it arises or what would be required to assure that decentralized mutual adjustment occurs effectively and reliably. Thus his definition of interdependence and its required form of coordination is somewhat tautological.

Following Levitt (2015), we note that reciprocal interdependence can take two forms—“compatible” vs. “contentious”—each requiring additional governance mechanisms to foster mutual adjustment in ways that optimize system level performance while minimizing the need to escalate decisions to the system integrator in case of an impasse.

- “Compatible-reciprocal” interdependence requires mutual adjustment to achieve a spatial or functional fit between the task outputs of the interdependent workers; however, achieving mutual adjustment to obtain the fit does not invoke conflicting sets of sub-goals for the involved actors. Compatible-reciprocal interdependence can thus be governed simply by requiring that frequent communication and confirmation occur between the involved actors, initially in choosing, and subsequently if and when revising, each of their detailed component specifications in order to maintain alignment between their respective components or subsystems.
- In contrast, “contentious-reciprocal” interdependence also requires mutual adjustment to achieve a spatial or functional fit between the outputs of the interdependent workers’ tasks; however, achieving alignment now invokes conflict between one or more of the sub-goals held by each worker—i.e., a given choice of the output that is more desirable to one is less desirable to the other, and vice versa.

An example of this type of workflow with conflicting subgoals is the design of an automobile door, for which the safety engineer prefers a heavy, reinforced steel door to protect the occupants from a side-impact, while the mechanical engineer designing the engine prefers the lightest possible door—an aluminum alloy door—to optimize acceleration and fuel consumption. In turn, the manufacturing engineer might prefer a lightweight steel door, which is easier to press and paint than an aluminum alloy door, but less safe than a heavy, reinforced steel door. And so on. For workflow with this kind of contentious-reciprocal interdependence, the workers need to negotiate tradeoffs among their respective subgoals to achieve mutual adjustment. If the workers in our automobile example have been acculturated to understand the trade-offs between safety, acceleration/fuel economy and ease of manufacturing, they are likely to be able to reach a mutually acceptable and system-level effective compromise in spite of subgoal conflict. If, in contrast, one or more of them hews to their own discipline's or business unit's parochial subgoals, the interdependent parties will likely reach an impasse in negotiation and fail to achieve mutual adjustment. This will require them to escalate the issue to a more senior manager with a global perspective on the trade-offs.

Contentious-reciprocal interdependence is thus the most complex and costly kind of interdependence to coordinate. We assert that in projects and business ecosystems, this kind of interdependence requires additional overarching governance to ensure that coordination among the interdependent specialized workers, business units, or firms occurs reliably and efficiently.

Appropriate governance of the specialized set of workers or supply chain partners in a complex and innovative cross-disciplinary project or business ecosystem is thus required to facilitate "decentralized mutual adjustment" effectively and efficiently without the need to escalate impasses. Developing evaluation criteria and rewards for workers or contracts for supply chain actors that share risks and rewards at the system level incentivizes and enables higher order goal alignment between interdependent subteams or firms who have contentious-reciprocal interdependence based on conflicts between their parochial subgoals. Integrated Project Delivery (IPD) in the construction of complex facilities like hospitals or airports is a form of alliance or relational contracting that uses both contractual and social mechanisms to secure system-level goal alignment among supply chain partners that would otherwise have contentious-reciprocal interdependence under the typical design-bid-build, fixed price project delivery approach (Hall and Lehtinen 2015).

Table 1 summarizes the different types of workflow interdependence and the associated coordination mechanisms (Thompson 1967) and governance mechanisms (Levitt 2015) for managing them.

Although this coordination and governance framework was originally developed for project-based tasks carried out by individuals and subgroups within a single organization, or teams employed by separate firms within projects, it can be extended to networks of ongoing activities performed by organizations within business ecosystems.

Table 1 Workflow interdependencies and mechanisms for their coordination and governance

Type of workflow	**Workflow characteristics**	**Coordination Mechanisms** (Thompson 1967)	**Governance Mechanisms** (Levitt 2015)
Pooled workflow	• Workers accomplish tasks independently of other workers • All tasks must be completed to achieve desired outcomes • There are no technical or timing dependencies between tasks	Coordination is achieved by specifying required outputs and workers skills, or by specifying detailed work processes.	Governance is achieved by specifying and tracking subsystem/component deliverables and quality requirements (and actor qualifications, if needed), and then verifying that the requirements have been met. Configuration Management processes and tools maintain records of the evolving detailed specifications for all subsystems that can be verified and certified.
Sequential workflow	Workers can start or complete tasks when others have completed part or all of prerequisite tasks on which they depend	Coordination is achieved by hierarchical scheduling and rescheduling	Centralized governance of scheduling, and rescheduling to accommodate changes in scope or variance in delivery times, is carried out hierarchically by a system integrator that is at least one level in the above the interdependent actors in the project team or contractual hierarchy of the supply chain ecosystem. If actors are empowered, self-synchronized, decentralized governance can be deployed in which actors negotiate with one another to trade durations and start times to accommodate variance (Kim and Paulson 2003). Decentralized governance is “compatible” when there are compatible goals among actors and sufficient resources and time along the workflow sequence to accommodate variance in task start times and durations easily. Decentralized governance can become “contentious” when there are conflicting goals among actors and scarce resources along the workflow sequence.

Reciprocal workflow - compatible vs. contentious	Outputs of workers must “fit”– spatially or functionally– the output of other workers in one or more dimensions.	Coordination is achieved by frequent information sharing between the interdependent actors and rigorous tracking and communication of changes to their outputs made by any of the involved workers.	Governance of “compatible-reciprocal” interdependence, when there are no contentious subgoals among actors, requires ensuring that the involved parties share information when initial design decisions are being made and any time that subsystem specifications change. Configuration management processes and tools can be used to formalize and impose rigor on this information sharing and updating process for both compatible and contentious-reciprocal interdependence. Governance of contentious-reciprocal interdependence, when actors have conflicting subgoals, is intended to ensure that the involved actors negotiate to make tradeoffs among their conflicting subgoals in ways that optimize system-level outcomes, rather than parochial subgoals. Governance of this kind of interdependence is the most challenging and nuanced. System integrators must develop a shared project identity in the team; constantly communicate high level goals to participants; and, when issues escalate due to impasses in negotiations, “teach the involved actors how to decide,” rather than “telling them what to do.”

4. Framework: initial propositions

The first step in analyzing the optimal governance system for a functional investment is to determine the boundaries of the business ecosystem in which the investment is embedded. For instance, defining short sea shipping in the Baltic as the business ecosystem boundaries for a sea-going cargo vessel will mean that the efficiency, or performance, of that ecosystem will be the foremost dependent variable in developing a *functional* vessel. Having defined the boundaries, the next step is to analyze the interdependencies in the ecosystem. In short sea shipping, the business ecosystem involves everything from the vessel, i.e. the specific investment being considered, to ports and export industries. The competitiveness of the short sea shipping business ecosystem depends on the entire system, meaning that it is vulnerable to poor performance in any one part of the system. The performance of such an industrial investment and the potential for generating more value at the system level will inevitably depend on the integration of the activities, workflows, resources, and actors across the different parts of the ecosystem and through the different phases of the focal investment's lifecycle.

We propose that, by analyzing the critical resource ties, activity links, and actor bonds that span sub-system boundaries and phases of an investment lifecycle, it is possible to develop a governance model for delivering functional investments that can generate greater system value by aligning those interactions. The key premise in improving value creation stems from the fact that different types of critical interdependencies—pooled, sequential, reciprocal—are often not governed appropriately, thereby reducing the potential for a business ecosystem to function well as a whole. In particular, inadequate governance of contentious-reciprocal interdependencies can lead to sub-optimization at the level of individual actors and parts of the business ecosystem instead of motivating the actors to achieve higher efficiency across the total ecosystem.

Applying this premise uncovers many avenues for unlocking greater system value creation. First, resource complementarity can be underutilized in a given business ecosystem when various technologically or functionally interconnected resources are not adequately coordinated, for example, in the absence of interaction between actors that control them (Harrison and Håkansson 2006). Moreover, the same resource can be controlled at different times during its lifecycle by various actors whose subgoals may be contentious or misaligned. Second, there can be opportunities to generate network externalities, i.e. greater system benefits, if previously unconnected resources, actors, or activities are embedded in broader ecosystem structures to achieve critical mass. A third approach is to address old, existing interactions that are actually hindering higher value creation at the ecosystem level. Remedying such blockages and creating space for new actor bonds, resource ties, and activity links can improve overall system performance.

Given the complexity of the analysis, it is crucial to choose the right starting point. As our interest is in how business ecosystems need to be governed in order to deliver functional investments, we start the analysis from the investment that is intended to improve the overall ecosystem efficiency. The first step is to analyze how the resources, actors, and activities interact over the lifecycle of the focal investment and across the business ecosystem, specifically focusing on which resource ties exist or need to exist based on the technological interdependencies and premises described above. Then, it is possible to identify which activity links or workflows and related actor bonds enable those resource ties. Further, understanding the most important interdependencies between the respective parties will help to analyze whether current governance of this link is suitable, and if not, what type of governance will help achieve the functionality of the focal investment. The logic of such analysis is explicated further in section 5, where we analyze a concrete case of investment governance.

5. Case analysis

The case of a "functional vessel" offers an example of how the success and functionality of an investment is highly dependent on the surrounding business ecosystem. The current short sea logistics ecosystem in the focal area is characterized by a number of inefficiencies that make shipping—i.e. operation of vessels—economically and environmentally infeasible. At the same time, the shipbuilding process rests on a highly first-cost-oriented logic, creating impediments for designing and delivering vessels that are able to create greater benefits during operations over their lifecycle. A functional vessel, in this context, is an investment that fulfils its main function, i.e. transportation of cargo by sea, while showing good lifecycle performance in terms of sustainability – economically, environmentally, and socially – and helping to generate greater value compared to the current industrial organization.

Applying the framework described in section 4, the investment can be mapped along the dimensions of the vessel's lifecycle and ecosystem embeddedness (Figure 1). Certain resources are already connected through technological interdependencies or need to be connected to achieve greater functionality of the focal investment – the vessel – and of the overall short sea logistics ecosystem. For example, while it is the same vessel throughout the lifecycle of the respective investment, different actors control this resource at different phases, and their activities are often misaligned, preventing more value from being generated throughout the system.

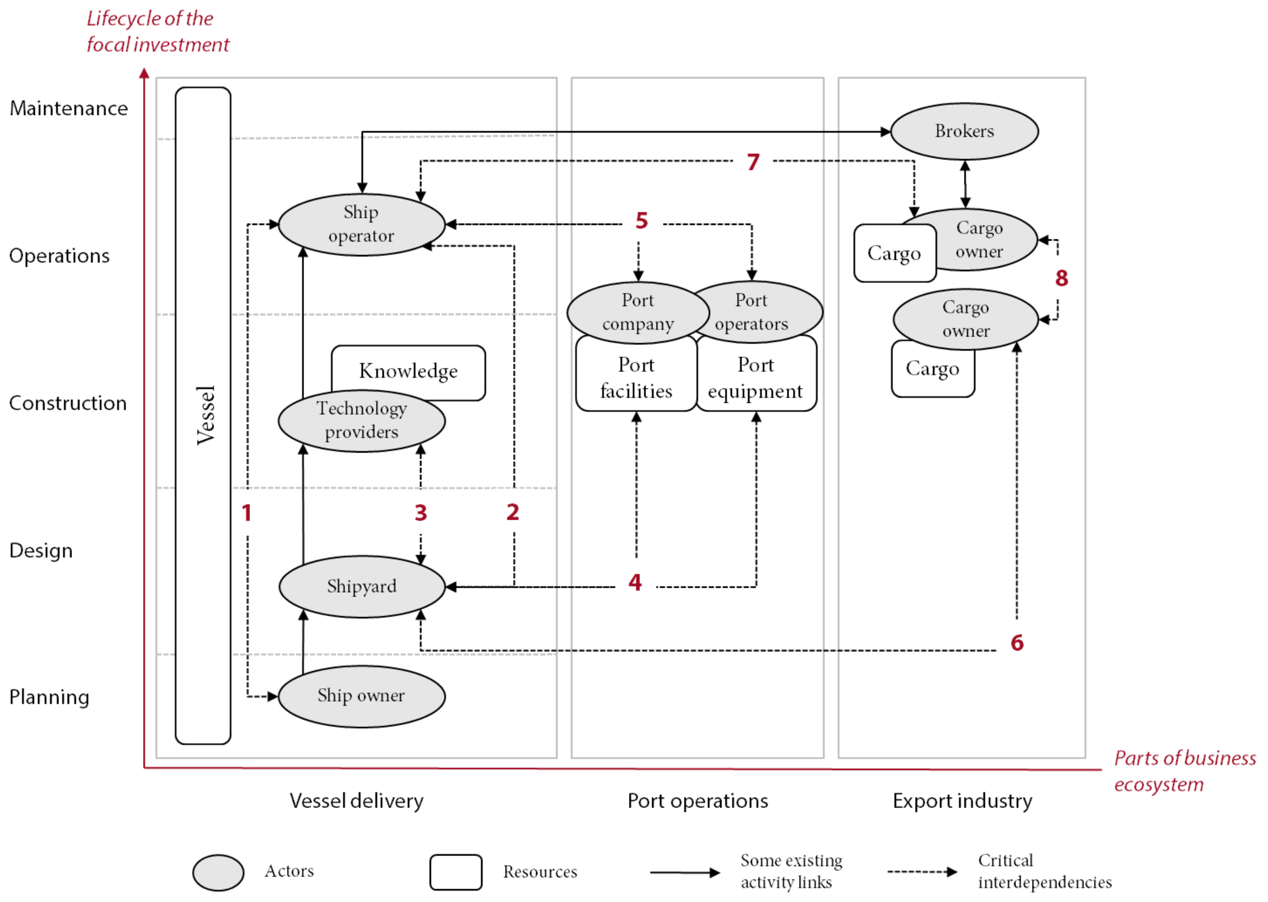

Figure 1 Mapping of critical interdependencies in business ecosystem structure in relation to the functional vessel investment. Problematic issues marked by numbers are analyzed in Table 2 and discussed in this section.

Another example is the tie between vessel and port facilities and equipment, including cranes for loading and unloading cargo, during the operations phase. This includes the availability of port facilities for a vessel to load and unload during operations, as well as the technological compatibility of the vessel with the facilities and equipment in a port. The need for technological compatibility makes it logical to coordinate the vessel design and its potential needs with the design and construction of better aligned port facilities and equipment.

These and other interdependencies are further analyzed in Table 2. We identified some of the most critical resource ties based on which resources need to be integrated in order to enable the efficient functioning of the vessel within the overall short sea logistics ecosystem. We then identified the type of dependency between the workflows of the respective actors. Understanding whether the character of the dependency is compatible or contentious was key to evaluating whether the currently employed governance is adequate or whether new governance mechanisms could be designed to resolve the tensions between different actors and their activities in a more globally optimal manner, while ensuring the functionality of the focal investment.

Table 2 Analysis of critical dependencies and their governance

	Critical interdependency	Type and character of interdependency	Current governance	Required governance	Enabled value creation
1	Vessel planning – vessel operation	***Sequential + Contentious-Reciprocal*** Shipowner invests in low-CAPEX standard vessel, while ship operator would benefit from more advanced vessel that shows lower operating costs and higher revenue potential.	Dependency is governed as sequential by excluding ship operator from planning phase. Transactional time charter contract between shipowner and ship operator does not facilitate resolving conflicting subgoals of actors in the value chain	The dependency needs to be governed as sequential+ contentious-reciprocal through an alliance between actors: • Forum for negotiation between shipowner and ship operator or merging the shipowner with ship operator. • Mechanism for redistributing benefits from the lifecycle performance of the vessel among ecosystem actors.	Focus on life cycle performance of the vessel, alignment of interests
2	Vessel design – vessel operation	***Sequential + Contentious-Reciprocal*** Yard follows requirements set by shipowner, reuses standard designs and bids for lowest-CAPEX systems from technology providers. Ship operator would benefit from more advanced vessel that has higher CAPEX, but shows lower operating costs and higher lifecycle revenue potential.	Dependency is governed as sequential by excluding ship operator from design phase. No formal relationship between yard and ship operator.	The dependency needs to be governed as sequential + contentious-reciprocal through an alliance between actors: • Forum for negotiation between yard and ship operator. • Mechanism for redistributing benefits from the improved lifecycle performance of the vessel. • Simulation of vessel operations during design phase	Focus on life cycle performance of the vessel, alignment of interests
3	Vessel design – vessel construction	***Sequential + Contentious-Reciprocal*** Yard follows requirements set by shipowner, reuses standard designs and bids for lowest-CAPEX systems from	Dependency is governed as sequential with information being exchanged only through the bidding process.	The dependency needs to be governed as sequential+ contentious-reciprocal through an alliance between actors:	Focus on life cycle performance of the vessel,

		technology providers. Technology providers would like to provide their latest innovations, but are not involved in vessel design.	Technology providers provide systems according to requirements.	• Forum for negotiation between technology providers, yard and ship operator. • Mechanism for redistributing benefits from the lifecycle performance of the vessel.	alignment of interests
4	Vessel design – design of port facilities and equipment	***Compatible-Reciprocal*** There is a need for compatibility of vessel and port facilities and equipment in order to enable logistic operations.	Dependency is governed as sequential by considering port facilities and equipment as a constraint for vessel design. Scarce information exchange.	The tasks should proceed in parallel and the dependency needs to be governed as compatible-reciprocal through: • Early and profound information exchange. • Co-design of vessel and port systems motivated by higher port fee for compatible ports.	Ensured compatibility or system innovation
5	Vessel operation – operation of port facilities and equipment	***Sequential*** Delays in port activities cause delays in vessel operation, reducing efficiency of vessel utilization.	Transactional relationship between ship operator and port operators leads to lack of governance of "just-in-time" operations. "First come, first served" principle in port operations makes scheduling very uncertain.	The dependency needs to be governed through real-time, collaborative decentralized scheduling: • Transparent and extensive information flow in order to enable planning and 'just-in-time' operations. • Parallelization of activities, such as notification of arrival, enabled by ICT technology. • Negotiations among multiple ships and port about timing and sequencing of loading, unloading. Bidding for port slots can be introduced as described in Kim and Paulson (2003)	Efficient value chain
6	Vessel design – cargo transportation	***Compatible-Reciprocal*** There is a need for compatibility of vessel cargo hold and cargo to be transported in	Potential informal discussions between shipowner and prospective users – cargo	The dependency needs to be governed through:	Ensured compatibility and

		it, which ensures safe and efficient transportation.	owners, but no persistent activity link. Lack of real time communication.	• Early and extensive information exchange to enable best fit of vessel for cargo to be transported. • Cargo owners can be incentivized by improved quality of transportation.	potential for system innovation
7	Vessel operation – cargo transportation	***Contentious-Reciprocal*** Cargo owners are interested in lower freight rates and suitable delivery schedules, while ship operator is interested in higher freight rates and high vessel utilization.	Brokers act as intermediaries. However, they exploit the opacity of information flow between cargo owners and ship operators and do not facilitate efficient utilization of vessels or efficient transportation of cargo.	The dependency needs to be governed as contentious-reciprocal through resolving the conflict between parties: • Electronic market place for cargo that enables more transparent information exchange and sets optimum freight rate. • More long-term contracts between cargo owners and ship operator in order to facilitate logistics planning.	System-level optimization of cargo flows and efficient value chain
8	Cargo transportation – cargo transportation	***Pooled + Contentious-Reciprocal*** Cargos of different cargo owners can be combined on vessels in order to increase vessel utilization and efficiency of the logistical chain	Lack of coordination between cargo owners in terms of production planning and reluctance to allow ship operator to combine several cargos in one shipment prevents higher value creation.	The dependency needs to be governed as pooled + contentious-reciprocal through resolving the conflict between parties and ensuring compatibility of the activities: • The use of new cargo handling technology on a vessel and a standard slot system for organizing transportation can provide proper coordination of cargo combination on vessels and increased vessel utilization while reducing transportation costs.	Ensured compatibility and system-level optimization

The first step in the analysis of interdependencies that affect the value generated by the focal investment is to explore the shipbuilding process and its effect on the lifecycle performance of the vessel. As mentioned earlier, the ship is a key resource in this ecosystem that is controlled and affected by different actors at various stages of its lifecycle. The shipowner is the actor that makes the decision about key characteristics of the vessel during the design and planning phase, such as its size, tonnage, suitability for certain cargos, while the ship operator is the one to operate the vessel during operations phase (interdependency #1 in Table 2). Often the two actors are connected by a rather transactional time-charter party agreement, which allows ship operator to charter and use the vessel of the shipowner for a certain price and during a period of time. In this situation, the information about actual operations is not communicated back to the shipowner, no "feedback for design" is generated, and thus the activity of defining future ship specifications is not connected to the activity of operating vessels. Since the shipowner is not involved in, nor benefits from, the operations of the vessel, there is no motivation for the actor to invest in more advanced and potentially more expensive technology that could lead to greater lifecycle benefits, such as reduced fuel consumption, decreased costs of cargo, fewer cleaning requirements during operations, and timely vessel maintenance to reduce operating time lost due to downtime.

Further vertical fragmentation along the vessel lifecycle is caused by the highly cost-oriented business model of a yard, which is a technical integrator and the major actor in designing the vessel. While the shipowner is focused on building the least expensive vessel that can be chartered out, the shipyard strives to reuse existing designs and bid for the lowest construction cost among the multitude of technology providers (interdependency #2 in Table 2). An adjacent problem is the lack of a link between the technological knowledge of various technology providers to the design and planning process (interdependency #3 in Table 2). Due to the cost-oriented bidding, there is no forum for proposing more advanced designs by technology providers, even if they have the requisite knowledge.

The analysis of the first three dependencies reveals that the activities and interests of actors controlling the vessel at the early planning and design phases and those involved in the later operations phase are currently not only sequential, but also contentious-reciprocal. This dependency is currently governed by organizing the activities as sequential, thereby removing the need for mutual adjustment, but at the same time reducing the potential for achieving lifecycle benefits. Thus, in order to unleash the potential for increased lifecycle performance of the vessel, there is a need to address, rather than avoid, the contentious nature of dependency between the activities of the named actors and move them into a concurrent co-design mode.

One potential solution designed during this research project is to create an alliance that would virtually integrate the actors that are critical during the lifecycle of a vessel. This could take place using forms of contracting that align the actors' interests and incentivize them to invest their best knowledge and resources in: (1) creating a vessel that will have the potential to achieve greater lifecycle performance, and (2) ensuring that the vessel operates in the intended manner. Such actors would include the ship operator, the yard, and key technology providers. The alliance would be responsible for the design and construction of the vessel, on one hand, and for the operation and maintenance, on the other hand.

By sharing the profit generated during lifecycle vessel operation, the participants should be motivated in a number of new and more globally optimal ways. Technology providers are incentivized to adjust the capital expenditure for a vessel based on a value-driven rather than cost-driven logic and to use their best knowledge to design and maintain the vessel in such a way that operations are not disrupted. Ship operators utilize their knowledge to provide input for the design of the vessel based on the current market situation rather than being driven purely by first cost concerns. With this combined input, designers can simulate vessel construction and operations to help align the planning activities of a number of crucial actors within the alliance, as well as with potential consumers of logistics services.

The next step is to analyze the interdependencies with other parts of the larger business ecosystem which are crucial for the functionality and sustainability of the focal vessel investment. One such link in the focal case is the dependence of vessel operations on the activities in ports and on port facilities and equipment. There is a direct technological link between the vessel and port facilities and equipment in terms of, e.g., the size of vessels that are allowed to a certain port quay, capacity of cargo handling facilities in the port, compatibility of cargo handling systems on the vessel with those at the port, etc. (interdependency #4 in Table 2). Since such interdependency is compatible-reciprocal, there is a need for more proactive governance, which would enable coordination between the design of the vessel and the properties of equipment and facilities in relevant ports. This can be achieved by adjusting vessel design to fit certain conditions related to ports as well as by jointly designing vessel-port solutions. One of the solutions proposed within the focal research project is to develop a specific technology for separating, storing, and transporting cargo on vessels, which would potentially require a different cargo handling process in ports. Although this requires a system-wide shift and naturally brings uncertainty, the attempt to achieve technological alignment between vessels and ports can spur more intensive information exchange and workflow alignment as well.

Yet another dependency between vessel and port activities of the ecosystem exists in the operations phase (interdependency #5 in Table 2). Currently, the system for managing vessel arrivals at ports significantly undermines the value creation potential of a vessel. For example, the complicated reporting and notification procedures, as well as highly inflexible working time of stevedoring companies force vessels to spend significant time in ports idling, while not generating any profit. In addition to that, the current “first come first served” principle creates the incentive to increase sailing speed when approaching ports, which increases fuel consumption and therefore the economic and environmental costs of operating a vessel. The relationship between ship operators and ports is transactional, and the processes at ports are highly institutionalized, making it extremely challenging to alter the current ways of working. Greater transparency and the elimination of unnecessary processes would increase overall efficiency and could be achieved by increased information exchange with port operators. This would not only facilitate communication but enhance planning, scheduling, and parallelization of port operations.

The last critical set of dependencies analyzed within this case are those between vessel and the cargo transported at different phases of the vessel’s lifecycle. Industrial cargo owners are the ultimate users of logistics services. Thus, vessel operations need to be compatible with industrial operations, including type of cargo transported, frequency, and routes. Already during the design phase, it is crucial to identify operating profiles in order to design a functional vessel (interdependency #6 in Table 2). In order to do so, designers need information on cargo flows during the planning stage. However, the demand uncertainty for many kinds of cargo makes it economically unadvisable to build vessels dedicated to one type of cargo or one customer. There is a need to govern the pooled and contentious-reciprocal interdependency between different types of cargo (interdependency #8 in Table 2). Currently, cargo owners are reluctant to combine their shipments with others, due to the assumed quality risks and prospective schedule delays. Our research identified the potential of introducing new cargo handling technology on the vessel, which would address the conflicting interests of various cargo owners. The opportunity to safely separate different types of cargo and efficiently combine different cargos on different routes would resolve the contentious character of this interdependency and allow for increased vessel utilization while still delivering greater value to the end customers. Coordination can be further facilitated by a new resource – an electronic marketplace for cargo transport. This solution would address the existing lack of efficient governance of the contentious-reciprocal interdependence between cargo owners and ship operators, which is currently bridged by cargo brokers in a somewhat opaque and non-optimal manner (interdependency #7 in Table 2).

We have identified which workflow interdependencies affect the value created by a functional vessel and analyzed how the governance of interdependencies between respective actors and activities needs to be adjusted. One of our major findings is that value creation is being hindered by ignoring the contentious-reciprocal character of some interdependencies. This reduces ecosystem efficiency and functionality of a given investment. New governance structures and systems that address the contentious character of existing interdependencies and create a shared interest for the crucial actors in the value chain can enhance the lifecycle performance of the investment.

The interdependencies spanning the boundaries of other sub-systems in the business ecosystem usually require compatibility of those systems and open avenues for system innovation and network externalities. Proper governance mechanisms for such compatible-reciprocal interdependencies should support extensive, transparent information sharing and thereby facilitate mutual adjustment for optimal outcomes at the ecosystem level. A remaining key challenge is to identify mechanisms that would incentivize the actors that are currently outside the boundaries of the focal investment value chain to engage in transparent communication and information sharing.

6. Discussion and conclusions

Functional investments require a holistic form of ecosystem governance that focuses more broadly on the overall ecosystem performance than on the individual firm's investment or project boundary. To design such governance systems, it is essential to understand how the focal investment is embedded in a larger business ecosystem and follow the lifecycle of the investment. The mapping of ecosystem structure needs to be guided by the recognition of which interdependencies define the functionality of the focal investment and thus the efficiency of the larger business ecosystem. As demonstrated in the case analysis, mature business ecosystems can become very fragmented and hence suboptimal. As governance models become institutionalized over time, it is increasingly challenging for actors to cooperate in achieving system goals. Moreover, such fragmentation may lead to the situation where various actors, all of whom are part of a value chain or business ecosystem, acquire conflicting goals. If governance of these interdependencies is not adjusted, this can lead to the failure in achieving the ultimate system goal and the success of an investment.

With this framework, we propose that governance of investments needs to be based on life-cycle systemic incentives in order to achieve ecosystem efficiency and investment functionality. We begin by asserting that ecosystems are built up of interdependent parts – actors, resources, and activities – and that governance of a functional investment is achieved by addressing the interdependencies between those parts. Understanding the types of interdependencies and analyzing the current governance should highlight the need for different governance mechanisms to enhance system value creation. Extending Levitt's (2015) framework to analyze interdependencies between organizations at the ecosystem level, we find that reciprocal types of interdependencies in fragmented business ecosystems can have either a compatible or contentious character. Their primary governance, coordination, and value creation mechanisms must differ, as presented in Table 3 and explained below.

Table 3 Business ecosystem governance framework

Type of interdependence	Primary governance mechanism	Primary coordination mechanism	Primary value creation mechanism
Compatible	Relationship and network governance	Self-organized relationships and networks, information sharing	Value chain, network externalities
Contentious	Real or virtual hierarchy	Organized business ecosystem to facilitate mutual adjustment based on ecosystem-level outcomes	Economies of scale, system level optimization

Compatible interdependence can be governed through contracts and networks of relationships. In some cases governance does not have to provide much intervention, since the interdependence is compatible, and the potential for generating higher system value by aligning activities is readily apparent to all participants. Decentralized self-organized relationships and transparent and timely information sharing should suffice in such situations. However, large, complex business ecosystems often lack the formal mechanisms to align the interests of actors from different parts of the system. In such cases, effective governance requires more deliberate attention to relationships within the system. We call this *compatible-reciprocal interdependence governance*.

Compatible interdependencies require regular and transparent information flows between relevant actors and tighter interconnections between their activities. For sequential interdependencies, this can be achieved through formal agreements between different actors in a value chain to exercise “just-in-time” operations, or through careful relationship management to achieve higher transparency and improve the scheduling and sequencing of various actors’ activities. In reciprocal interdependencies, early involvement of actors—for example, in the design of a vessel—can ensure compatibility throughout the business ecosystem. Absent a formal mechanism for involving certain actors, relationship management can take the form of incentives based on expected system benefits. Compatible interdependence governance creates value by integrating the value chain and establishing incentives across the business ecosystem.

Contentious-reciprocal interdependence can be governed by contract and by managing networks of relationships. The governance has to intervene when there are contentious interdependencies and mutual adjustment may result in local vs. global optimization or impasse. Often these situations require escalation of issues, and the governance needs mechanisms to reconcile conflicting subgoals among ecosystem actors. We call this *contentious-reciprocal interdependence governance*. Hierarchical mechanisms are effective in resolving such incompatibilities, and the most common example is the management hierarchy with a chain of command and/or delegated responsibilities. However, hierarchies can also be virtual, meaning that the network of contracts among the parties can contain terms that incorporate routines, principles, and rules that encompass several organizations (Stinchcombe 1985).

In the case of the short sea logistics ecosystem, a number of contentious-reciprocal interdependencies were initially coordinated as compatible, through self-organizing networks. Conflicting subgoals of different actors, whose activities were reciprocal, sequential, or pooled, led directly to underperformance in overall ecosystem efficiency. This kind of result, all too common in complex long-term projects, can be explained by misalignents within business ecosystems and industry fragmentation—both of which evolve naturally over time as actors' goals differ and local optimization efforts lead inexorably to sub-optimization of the overall business ecosystem. When making a functional investment, it is therefore crucial to identify such contentious interdependencies and address them. Concrete governance mechanisms can include alliances and other means to alter actors' identities and relationships; simulation and co-creation ICT tools can help resolve conflicts between different actors and their activities. Contentious-reciprocal interdependence governance creates value primarily by restructuring business ecosystems for virtual integration that combines the fragmented network into a single "macrofirm" (Dioguardi 1983). Done correctly, virtual integration creates life-cycle long, system-wide economies of scale and realigns the activities of actors so they are not contentious, but rather are aligned towards a common system goal.

The case of the sea logistics ecosystem showed some critical dependencies that lacked governance or were governed in a manner that obstructed system value creation and therefore the functionality of a vessel investment. By applying the framework we developed to analyze these interdependencies, we were able to pinpoint the faults in the underlying governance mechanisms and to propose more suitable governance models. We recognize that, as new governance mechanisms are implemented, the business ecosystem will inevitably change. Continued analysis may identify new dependencies that are critical for the functionality of the investment, and therefore in need of governance.

Future research could add much value by studying how institutions and projects (Jooste *et al.* 2011) relate to the governance of workflow interdependence in business ecosystems. The framework we have developed can also be used for the analysis of dependencies in the business ecosystem from an investment perspective, followed by decisions on appropriate governance. We thus contribute to the research on business ecosystems by proposing a practical framework for embedding an ecosystem perspective in the governance of individual investments. We also uncover the logic for the intentional shaping of business ecosystems towards higher efficiency as opposed to perceiving them as purely evolutionary and dependent on individual companies taking the lead in their restructuring in order to appropriate maximum system value (Moore 1996).

Governance of business ecosystems is a promising area for future research. We use Ostrom's theories of how a commons can be partly self-organized, in that rules are institutionalized voluntarily in the system (Ostrom 1990, Ostrom *et al.* 1999, 2010). Such a view challenges the traditional model of forceful intervention by system integrators or regulatory institutions, and suggests that institutions can take on the role of facilitators of self-organizing coordination by actors in the business ecosystem. Future research should explore what kinds of governance can be used for self-organizing workflow coordination, and under which conditions it is suitable to apply it.

Our framework keeps the focus on efficiency over the life of the investment. We propose that constantly monitoring the physical state of the investment can enable system integrators to adapt their governance modes to realign the ecosystem with changing real-word conditions over time. Sustainable systemic performance improvements can be achieved by connecting the performance measurement of the actual physical investment to the ecosystem (Sundholm *et al.* 2015). Future research should expand the view on the focal investment to cover larger parts of the ecosystem (ports, export industry) and to identify the overall benefit of maximizing ecosystem efficiency.

Formal contracts are not always sufficient to manage the fragmented internal boundaries of a business ecosystem and the conflicting subgoals of its constituent parts. Our findings point to the need for shifting from transactional to relational business practices (Henisz *et al.* 2012), which are reflected in novel governance mechanisms that enable cooperation, transparency, and joint value creation.

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