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You don't forget where you come from: Linking formation and operations in publicly funded innovation networks

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Abstract

Publicly funded innovation networks (PFINs) are an increasing form of organising joint innovation activities. Yet, little is known about this form of organisation which mixes characteristics of centralised and de-centralised innovation networks. This research investigates how processes of network formation affect its operation in PFINs as a hybrid form between centralised and de-centralised networks. Presenting rich data from a PFIN in the Scandinavian maritime industry, the findings show three patterns linking network formation and operation. The first pattern – well-aligned centralised and de-centralised approaches - in network formation resulted in well-functioning network operation. The second pattern - misalignment between centralised and de-centralised approaches in network formation resulted in stagnating innovation activities during network operation. The third pattern - a pre-dominant de-centralised approach during network formation resulted in unconnected sub-activities during network operation. This research contributes by showing the importance of utilising both centralised and de-centralised approaches and aligning them to enable well-functioning network formation and operation.

Keywords: publicly funded innovation networks, case study, maritime industry, governance, inter-organisational relationships

1. Introduction

Publicly Funded Innovation Networks (PFINs) are an increasing source of innovation aimed at solving societal challenges (Maroto et al. 2016), developing national and international innovativeness (Youtie et al. 2017), and improving competitiveness (Toole 2012, Kalsaas 2013). Similar to general innovation networks, PFINs often aim at developing new products and services (Ritter and Gemünden 2003, Song et al. 2016) where collective benefits can be created faster, at less cost, with greater flexibility, and with less risk (Larsson et al. 1998, Michaelides et al. 2013). In contrast to other innovation networks, PFINs often implement policy (Scandura 2016) and as such are often initiated by a public funding body, such as national government funds or the European Commission, which provides the financial resources needed to bring together a consortium of different organisations including manufacturers, research institutes, universities, and consultancies to innovate collaboratively (Cano-Kollmann et al. 2016, Scandura 2016). Thus, PFINs have a lot of characteristics of centralised innovation networks where one organisation acts as the hub and directs efforts of network management (Uzzi 1997, Rampersad et al. 2010).

PFINs also share characteristics with de-centralised innovation networks including the need to develop trust (Delbufalo 2017), knowledge creation (Dooley et al. 2013), knowledge sharing (Alexander and Childe 2013), and quality management (Roldán Bravo et al. 2017). De-centralised networks rely on self-governance by the participating organisations (Aarikka-Stenroos and Sandberg 2012). As a result, PFINs are characterised by a trade-off between centralised and de-centralised innovation networks including central administration by a network coordinator but de-central innovation activities by the individual partner organisations (Spanos and Vonortas

2012). The alignment between centralised and de-centralised characteristics provides unique management challenges for PFINs including governance of the inter-organisational relationships to achieve innovation goals (Bunduchi 2013). Particularly the effectiveness and efficiency of PFINs have been criticised by practitioners because of PFINs heavy administration apparatus, challenging the ability to achieve innovation objectives with the best use of public funding. Despite the importance of PFINs in practice, relatively little is known about effective management practices of these organisational structures.

As an emerging research field, relatively few insights exist of PFINs. Most existing works on PFINs focus on the achievement of different innovation outcomes including the development of public and industry infrastructure (Cumming and Fischer 2012, Link and Wright 2015). However, research on (general) innovation networks shows that management activities have been studied in two stages of network formation and operation. Formation refers to the creation of the network including individual organisation's motivation for joining and partner selection (Sydow and Windeler 1998, Bunduchi 2013). Network operations refer to governance, management, evolution, and performance of the network in terms of reaching innovation goals (Spanos and Vonortas 2012, Aboelmaged 2014, Santa et al. 2014). Each of these stages individually is well explored with insights focusing on collaboration processes (Garengo and Panizzolo 2013, Roldán Bravo et al. 2017), inter-organisational relationships (Autry and Golobic 2010, Kreye 2017), and operational performance (Aboelmaged 2014, Santa et al. 2014). However, in innovation networks, it is necessary to investigate the link between network formation as a determinant of network operations (Esposito De Falco et al. 2017). The reason for this is the long-term

nature of many Business-to-Business relationships (Kreye 2017) where present actions are influenced by past interactions and experiences (Autry and Golicic 2010). As a result, the way these relationships are created and established affects future collaboration during network operation and ultimately the achievement of PFIN goals (Matinheikki et al. 2017). While few studies have explored this link for innovation networks in general (Gulati et al. 2000, Harryson et al. 2008), no systematic insights exist for PFINs based on the unique combination of centralised and de-centralised processes. This is a gap this paper aims to address.

This research investigates the following research question: How does the formation process of publicly funded innovation networks affect their operation? We look specifically at the alignment between centralised and de-centralised approaches to network formation and the effect of this alignment on processes of network operation. We present evidence from a single case of a PFIN in the maritime industry, consisting of 37 organisations. Based on insights from both qualitative and quantitative data collection, our findings show the effects of network formation on network operations in three main patterns. First, alignment between centralised and de-centralised approaches to network formation resulted in well-functioning network operation. Second, misalignment between centralised and de-centralised approaches in network formation resulted in stagnating innovation activities during network operation. Third, a pre-dominant de-centralised approach during network formation resulted in unconnected sub-activities during network operation. This research contributes to the operations management literature by linking network formation and network operation and identifying the importance of aligned centralised and de-

centralised approaches to ensure achievement of innovation goals. We present important contributions to practice based on our insights.

2. Literature review

An innovation network is an organisational form between a wide range of distinct but related organisations that combine resources for innovation purposes including the development of new products and services (Aarikka-Stenroos and Sandberg 2012, Aarikka-Stenroos et al. 2017). Publicly funded innovation networks (PFINs) are specific types of innovation networks which often arise from external pressures creating societal challenges, such as environmental sustainability (Acciaro et al. 2014). For example, in the maritime industry disasters such as the Exxon Valdez 1989, Erika's 1999, and Prestige's 2002 oil spills increased overall environmental awareness and created an urgency for policy makers to implement environmentally friendly policy measures and improve the sustainability of whole industrial sectors (Perunovic et al. 2016). PFINs are also different from other innovation networks because they require alignment between central administration (to fulfil the external pressures they face) and de-central innovation activities from the individual organisations. This need for alignment creates a unique setting for inter-organisational relationships in PFINs.

Inter-organisational relationships are dynamic in nature as relationship strength fluctuates over time based on performance outcomes and experience (Autry and Golicic 2010, Kreye et al. 2014). Past joint experience and reputation affect the intention of collaborating again in the future (Cousins and Lawson 2007). This means that the way relationships are created during network formation affects how these relationships play out over time during network operations because expectations are

built with regard to the partners' commitment, solidarity and open communication (Jap and Anderson 2007). Often, the relationship length determines the governance mechanisms employed within inter-organisational relationships (Kreye et al. 2015, Selviaridis 2016). This dynamic nature may affect particularly innovation networks because of the importance of trust (Delbufalo 2017), joint innovation capabilities (Perunovic et al. 2016) and collaboration (Kalsas 2013). It is thus important to take a dynamic view on innovation networks and integrate processes of network formation as determinants of network operation.

Research to date has investigated mostly the performance benefits of PFINs in terms of economic benefits (Cumming and Fischer 2012, Maroto et al. 2016) and motivating long-term innovation activities (Spanos and Vonortas 2012, Toole 2012, Cano-Kollmann et al. 2016, Scandura 2016). Other works have focused on the operational performance of innovation networks (Aboelmaged 2014, Santa et al. 2014). However, little research has investigated the dynamic governance effects from formation to operation within PFINs. One notable exemption here are Buchmann and Pyka (2015) who investigated the evolution of PFINs in terms of collaboration activities and knowledge sharing. However, limited insights exist on the alignment between centralised and de-centralised processes within PFINs and how these support or prohibit successful formation and operations.

2.1 Network formation

Network formation describes the process of finding suitable partners for the innovation task(s) and integrating operations purposefully to achieve the innovation goal (Sydow and Windeler 1998). PFINs typically form around a specific market

opportunity and last only the length of that opportunity (Anderson et al. 1994, Aarikka-Stenroos et al. 2017). This means that already in network formation, the disintegration of a PFIN is often defined in terms of innovation goals (Thorelli 1986, Spanos and Vonortas 2012, Link and Wright 2015). Thus, the formation of PFINs often focuses on defining these innovation achievements and the individual organisation's roles and responsibilities within the network (Chesbrough and Prencipe 2008).

The literature describes why and how organisations engage in innovation networks (Chesbrough and Prencipe 2008, Garengo and Panizzolo 2013). Ritter and Gemünden (2003) described that creating an innovation network is strategically relevant if i) the company operates in a business environment characterized by time-based competition and ii) the company is unfamiliar with the pace-technology. In decentralised networks, the choice of partners often relies on existing relationships between organisations prior to the network formation (Hagedoorn et al. 2006). For example, Huggins et al. (2012) describe that network features can be reinforced by geographic proximity because of existing relationships and path dependency of prior interactions. Here, partner's motives for joining a network are important (Jarillo 1988). These motives include gaining access to external knowledge and external capabilities (Powell et al. 1996, Hagedoorn et al. 2006, 2011) and access to complementary technology and new markets (Tidd 1995, Kalsaas 2013). In centralised networks, however, partners are typically chosen by a hub (Jarillo 1988, Gulati et al. 2000). Here, political factors often play an important role as prestige can be a major influence (Stuart 1998) signifying and legitimizing a company's presence on the market (Sydow and Windeler 1998). This may also affect financing mechanisms which are not available to the individual organisation (Jarillo 1988, Anderson et al. 1994). Partner choice in

PFINs with characteristics of centralised and de-centralised networks can thus lead to frictions in network formation because hub-imposed partner selection may not be well received and accepted by the individual organisations.

2.2 Network operations

Network operation concerns the management of processes aimed at achieving innovation goals and requires strong inter-organisational relationships (Jarillo 1988, Dolfsma and Van der Eijk 2016). Inter-organisational relationships define the social routines and behaviour which are utilised to effectively create, exchange and exploit knowledge and skills (Kreye et al. 2015, Giovannetti and Piga 2017). The nature of the relationship describes the quality of collaboration (Ring and van de Ven 1994) through shared goals (Aarikka-Stenroos and Sandberg 2012), frequent and open communication and joint decision making (Birkinshaw et al. 2006). Specifically the importance of knowledge sharing has been highlighted in this context (Dyer and Nobeoka 2000, Cumming and Fischer 2012, Toole 2012, Alexander and Childe 2013, Dooley et al. 2013, Cano-Kollmann et al. 2016, Kreye 2017) as it enables achieving innovation goals (Spanos and Vonortas 2012, Kalsaas 2013). However, a major concern here is to prevent free riders and preventing undesirable knowledge spill overs between potential competitors (Dyer and Nobeoka 2000, Rampersad et al. 2010, Shaw and Burgess 2013). This is where fundamentally different governance mechanisms have been explored in the literature on centralised and de-centralised networks.

In centralised innovation networks, the challenges are solved by the network hub and their power to influence network operations (Uzzi 1997). Power defines the *“ability to influence the decisions or actions of others”* (Thorelli 1986, p. 38) meaning

that the hub can enforce processes and guidelines through meta-coordination that ensure that individual firms contribute to augmentation of network resources and effectiveness (Sydow and Windeler 1998). It is also the hub that punishes lack of contribution through potentially excluding an organisation from the innovation network (Sturgeon et al. 2008).

In de-centralised innovation networks, in contrast, this agency does not exist and partnering organisations have to ensure relational effectiveness through self-governance. This links to descriptions in the project management literature (Tatikonda and Montoya-Weiss. 2001) where inter-organisational trust has been highlighted as an important factor (Jarillo 1988). Inter-organisational trust is fostered through openness, reciprocity and non-contractual contributions showing the intentions of partnering organisations and commitment to the network (Uzzi 1997, Kreye 2017). Trust is also influenced by long-term shared values suggesting that partner self-selection may encourage close relationships with “thick” information channels (Sydow and Windeler 1998) to exchange tacit and proprietary know-how (Hofman et al. 2017). This creates complex social interactions on different levels that inhibit free-rider behaviour. Thus, centralised and de-centralised networks rely on fundamentally different approaches to network governance, potentially creating misalignments in PFINs.

2.3 Conceptual framework

We investigate our research question through the following conceptual framework defining the possible links between network formation and network operation in PFINs. We investigate the network formation through the process of partner choice (Jarillo 1988, Aarikka-Stenroos and Sandberg 2012) including the individual

organisations' motives for joining the network (Tidd 1995, Hagedoorn et al. 2011). We look at network operations through the nature of the inter-organisational relationships characterised by communication patterns, shared goals and decision-making processes (Hofman et al. 2017).

We study specifically the alignment between centralised and de-centralised approaches to network formation and the effect of this alignment on processes of network operation. We conceptualise alignment as the agreement between centralised and de-centralised approaches. Because PFINs have characteristics of both centralised networks (where network management centrally administers the network including initiation, definition of PFIN purpose and network management (Uzzi 1997, Rampersad et al. 2010)) and de-centralised networks (self-governance of participating organisations with need to develop trust, knowledge sharing and quality management (Aarikka-Stenroos and Sandberg 2012)), they face partly contradictory demands of these two governance structures. Thus alignment between these characteristics is important for PFINs to achieve the intended innovation goals (Matinheikki et al. 2017). Figure 1 depicts the conceptual framework, which we utilised to guide our empirical work.

Figure 1: Conceptual framework guiding the empirical investigations

3. Method

Because this research is exploratory in nature, we employ a qualitative research approach via a single case study (Childe 2011). The case study method is suitable for the purpose of this research because it enables us to investigate a context-specific phenomenon (Barratt et al. 2011) where factors such as policy and industry sector dynamics can be included in the analysis. Furthermore, it enables the researchers to collect rich data for an in-depth analysis (Yin 2009). The presented case is based on unique data access to a PFIN in the maritime industry which could be studied in its entirety from formation to operation. This offered rich insights into the dynamics within the network to answer the research question.

3.1 Case selection

The selected case focused on a PFIN in the maritime industry sponsored by a Scandinavian government. This case is appropriate for this research because the maritime industry has faced increasing pressures to innovate for improving specifically environmental sustainability which are achieved through PFINs (Perunovic et al. 2016). The specific case PFIN was selected based on theoretical criteria including the nature of organisations involved as well as practical criteria including data access. The aim of the case PFIN was to develop a new range of products and solutions to address the international environmental regulations in the maritime sector. The network consisted of fourteen innovation projects focused around the development of new products, services and business models. In total, 37 organisations participated in the network including ten equipment manufacturers (EMs 1-10), four universities (University 1-4), four research institutes (Research 1-4), six ship owners and operators (Owners 1-6),

eight consultants (Consultant 1-8), two designers (Designer 1-2), and three classification societies (Classification 1-3). Our study can thus be characterised as an embedded case where the innovation network included a large number of project partners and their ties, linked through projects. Table 1 gives an overview of the case PFIN with regard to projects.

Table 1: Description of the 14 projects of the case PFIN

Project	Brief description	Partnering organisations
1	Optimize the propulsion system on vessels by improving the working environment for the propeller. This was done by developing controllable pre-swirl fins.	EM1; Owner 1; University 1; Designer 1
2	Develop the basic control principle and embed it in control software, which can be implemented in standard hardware. The solution is to dynamically adjust shaft speed to follow the time-varying water inflow to propeller when sailing in waves in order to maximize total propulsion efficiency of any given propeller.	EM2, Owner 1; University 1, Consultant 1
3	Introduce a new concept of a Ro-Ro (Roll-on-Roll-off) vessel designed in a catamaran configuration for large volume maritime transport of road trailers and other classes of rolling cargo.	Classification 1; Universities 1- 2; Research 1; Designer 1; Consultant 2-5
4	Develop a performance management platform for decision support for ship management. The platform should support (i) the optimization of the transport and energy efficiency in technical and operational functions, (ii) the development of human awareness on energy efficiency, and (iii) shipping companies to document and improve environmental performance.	University 3; Research 2; Consultant 6; Owners 2-3
5	Develop an ICT-centred (information, communication and technology) system for energy optimization of ships – with a focus on working vessels and minor ferries with flexible operation profiles.	EM3; Owners 4-6; University 4; Research 3; Designer 2
6	Develop new gas valve train to enable the use of a higher gas pressure in two-stroke gas engines.	EMs 1, 4-5; Classification 2; Consultant 7; University 3
7	Burning off all types of fuels within liquid and gasses. (a) Liquid fuels: HFO, MDO, Diesel, Bio fuels, Ethanol, Methanol etc; (b) Gas fuels: Methane, Butane, Propane, Ethan, bio gasses etc.	EMs 6-7; University 1
8	Identify the causes of the high emissions of unburned methane and assign the best ways to reduce unburned methane in the exhaust from ship engines.	University 1; Research 4; EM1
9	Develop and manufacture liquefaction plants that will be connected to the NG network.	Consultant 8; University 1; EM 8
10	Investigate how emissions of PM (particular matter, black carbon, soot, etc) can be further reduced by optimizing scrubber design and propose robust and practical methods for approval and control of the scrubber system.	EMs 1, 7; University 1; Research 2
11	Development and validation of new antifouling paint for slow-steaming container vessels	EM 9, Owner 1, University 1

12	Provide the tools, mathematical models and knowledge needed for the industrial partners to supply optimal and competitive SCR technology solutions for ships	EMs 7, 10; University 1; Owner 1
13	Encapsulation technology will be employed to achieve a more controlled biocide release. An important innovation activity in the project is the incorporation of encapsulated biocides in hull coating formula.	EM 9; Research 4
14	Build a market case for in-service support of developed products and parts in other projects with the aim to integrate other projects through developing specific business cases in the industry.	University 2, Classification 3

3.2 Data collection

The empirical data were gathered via multiple sources of evidence (Yin 2018) including semi-structured interviews, survey, workshops, and secondary data. Each data collection method followed the basic rules of rigour and in combination they enabled triangulation of the findings (Yin 2018). Fourteen semi-structured interviews were held spanning twelve of the fourteen projects. We interviewed the project managers of projects 1, 2, 3, 4, 6, 7, 9, 10, 11, 12, and 13. We further interviewed project participants of projects 4 and 14. We contacted the interviewees directly and through the network manager. In addition, the network manager was interviewed to obtain insights from the network hub. The interviews were recorded and transcribed. The interviews were guided by a list of questions which focused on the network formation and operations including the conception of project proposals. These data were complemented with a quantitative survey of all project participants (60 in total) of which we received 44 complete responses. The survey investigated the concepts of network formation and inter-organisational relationships with regard to our conceptual framing. Furthermore, the network was governed by regular workshops which we utilised as a further data source. For example, in the kick-off meeting, the participating companies were asked to discuss specific research-related topics in their specific projects. These topics included relational involvement between each of the

partners which resulted in a diagram that showed the tie strengths for each project. Finally, secondary data, including the network proposal and project descriptions, were collected to ascertain to corroborate the collected insights.

3.3 Data analysis

The unit of analysis is the innovation network. To achieve a contextually detailed account of the case, the data analysis was undertaken iteratively (Miles et al. 2014). This involved analysing each of the data sources separately. The interviews, workshops, and secondary data were analysed qualitatively through coding (Miles et al. 2014). The data were initially coded in thematic categories based on the conceptual framework. Subsequently, the data were coded based on the researchers' understanding and interpretation of the data to systematically combine the empirical data analysis, collection and the literature (Miles et al. 2014, pp. 292–293). The coding structure (see Table 2 for excerpt) was created and refined iteratively by identifying links between the investigated concepts (Miles et al. 2014). The survey data was analysed quantitatively through descriptive statistics such as t-tests to supplement our qualitative insights. The data sources were then combined using triangulation to validate initial insights and increase reliability of our conclusions (Yin 2018).

Table 2: Excerpt of the coding structure

Second order codes	First-order codes	Level of analysis
Network formation		
Aligned processes	Emergent partner selection	Project level
	Emergent definition of project leadership	Project level
	Innovation-related motives for joining	Individual organisation
Misaligned processes	Dissonance between partners on project goals and roles	Project level
	Dissatisfaction with project set-up	Individual organisation

	Network-management interference in partner selection	Network level
De-centralised processes	Emergent partner selection	Project level
	Emergent definition of project goal	Project level
	Lacking practical project leadership	Project level
Network operation		
Aligned processes	Open communication between partners	Project level
	Aligned goals of project partners	Project level
	Issues with individual partner contributions	Project level
Misaligned processes	Circles of communication	Project level
	Lacking commitment by individual project partners	Project level
De-centralised processes	Unconnected project activities	Project level
	Limited knowledge flow	Project level
	Lacking integration between partners	Project level

4. Case observations

The case PFIN was initiated by the national government, with the aim of enhancing growth and innovation in the maritime industry. The specific objectives were defined with regard to a range of deliverables that were in the public's interest including job creation, economic growth of the maritime sector, the creation of public knowledge (scientific, industry and popular press publications), and the creation of new competencies on the labour market (university and industry courses and workshops).

The network funding application described this as follows: *“the industry is complex and diversified and cooperation between the different parties could be more efficient. In that sense, the [case PFIN] is an investment in the development of a strong common innovation model that will offer a central, competitive advantage for the Danish maritime industry”* (Funding application of the case PFIN). The anticipated impact would be an innovative industry sector that is internationally competitive as the Funding application of the case PFIN concluded *“After completion of the 14 projects in*

the Partnership, (...) Denmark will be recognized as one of the maritime leaders within environmental solutions.” The case PFIN thus constitutes a PFIN that targeted objectives of public policy on a national level.

The case PFIN was administered centrally by a steering committee which was created of key partners from the Board of Danish Maritime, members of several maritime-related industrial associations, and the network manager who would oversee the formation process, write the funding application, and administer the network operation. The network manager explained: *“It started running because of [the key partners]. There was one meeting where they actually showed their hands. And this started the backwards process from finances to the innovation idea.”* To recruit participating organisations, the network manager followed various approaches: *“We advertised articles in the local newspapers, conducted meetings across Denmark. I contacted people I know - I have a very large network and experience in the industry [from prior projects]. (...) We chose our contacts based on their competencies – what does the company bring to the table. Based on company type as well. We contacted [Danish Maritime] association members. The difficult thing was to navigate things with the powerful companies and the association.”* This shows the bi-directional approach to the case PFIN through both centralised and de-centralised activities.

4.1 Network formation

Network formation mirrored this two-sided approach. Initially, the projects were defined around twelve themes which guided the development of project proposals and chosen for their focus on publicly relevant topics. *“We invited to open meetings for each of these twelve themes to discuss possible innovation ideas and projects. [There*

was] an iterative process where sadly really good projects were leaving and really good new projects were coming in.”, explained the Network Manager. He continued *“This process was also influenced by political concerns where some projects had quite an easy ride through the formation to ensure that specific network partners remained within the final set-up”*.

The formation process resulted in the network structure depicted in Figure 2. Innovation activities focused on the project level as the Network manager explained: *“People are not part of [the case PFIN], they are part of their project.”* On project level many direct links existed where organisations collaborated directly for the purpose of the project outcome. However, on network level, few direct links existed creating structural holes in the network. For example, there was a structural hole between Project 5 and the rest of the network with no direct links. These issues were a direct result of the network formation and known to the network manager as described in the Funding application of the case PFIN: *“Even though there is no stringent project dependence (...) they all share the same goals and the coherence will strengthen over the span of the Partnership. During the project execution the leaders will ensure that potential collaboration opportunities and knowledge sharing between the projects is properly identified and executed.”* This shows that the level of collaboration on network level was a leadership task rather than part of the network structure.

Figure 2: Linkages in the case PFIN

Three patterns of alignment between centralised and de-centralised approaches emerged for network formation. The first pattern showed well-aligned processes of centralised and de-centralised network formation. An example was Project 1 as the Project owner and manager (Project 1) explained: *“You would try to sell the project for the other participants. And rather soon, there were four that were interested [in our project]. (...) And even though we were not nominated, we were soon the ones who took the lead in the project making a project description, getting the approval and consent from the other partners.”* Here, the choice of partners was frequently based on prior experience of working together. One example was described by the Project owner and manager of Project 10 (EM7): *“We have worked together with [EM1] for 30-40 years. We don’t have any overlap in business and we have a lot of trust and experience.”* This demonstrates the self-selection process between partners where both motives for joining the network and partner selection were aligned.

The second pattern showed misalignment between centralised and de-centralised approaches. For example, in Projects 4, 7, and 14, network formation was predominantly influenced through political considerations from the PFIN’s central network management. The Project manager (Consultant 6, Project 4) explained: *“[Prior partner] was out because Owner 3 changed their strategy because they had a new management. (...) this gave us the opportunity to bid on the front end and we did.”* In this case, the Project manager joined the project formation very late which affected the project operation as described later. Another example was Project 4 as explained by the Project manager (Consultant 6, Project 4): *“There were a lot of political issues about [Research 2] because we could not get around them. So the assignment was that we needed to find a way in which [Research 2] could stay in the project and that is of*

course a big challenge because [Research 2] is a competitor.” Projects with political pressure created difficulties already in the network formation as the Project participant of Project 14 (Class 3) explained: *“There was actual discussion whether they should pull the break and leave this entire project out of the proposal. But for some reason, they decided to keep it. And I think there was pressure from [University 2]. (...) So that was a political decision.”* Thus, the political consideration for enforced selection of partners in specific projects created difficulties in network formation.

The third pattern showed a de-centralised approach to partner selection. The project manager (Project 9, EM8) explained this as follows: *“we created a small partnership [where we also] look into the commercial market. This is where we involved [Consultant 8], it’s an old employee from here and he has his own consultancy company in energy. (...) And he had some connections to [University 1]. (...) So we made a small partnership very fast. And then we started to make a plan together with this and they brought in some really competent people and we could see immediately that they had some fantastic competencies.”* This shows a completely de-centralised approach to network formation where the partners were selected based on existing contacts following an emergent process. The partner selection for each of the 14 projects is summarised in Table 3.

Table 3: Main findings regarding motives and partner selection during network formation

Relationship pattern	Project	Motives	Partner selection
A - Well-aligned	1	Political motives to gain access to customers. Owner participate for political reasons, but chose project on good success potential and strategic fit	interest from four companies when project was presented, had worked together with Owner 1 and University 1, Designer 1 was new partner
	7	Capability-based motives to gain access to knowledge	A different university was preferred and University 1 was chosen based on a political decision. EM7 contacted EM6 because of prior contact and due to similar competences

	10	Finance based motives to gain access to financing	Long prior experience, complementarity of business capabilities and interest
	12	Capability-based and finance-based motives to gain access to knowledge and financing	Prior involvement with the partners by at least one project partner, trust
	13	Capability-based and finance-based motives to gain access to knowledge and financing	Previous working relationships and good experience
B – misalignment between centralised and de-centralised	2	Finance based motives to gain access to financing Owner participate for political reasons, but chose project on good success potential and strategic fit	Consultant 1 initiated the project and selected all partners. Previous relationships, together with necessary capabilities and competences were the primary drive in partner selection process.
	4	Capability-based motives to gain access to knowledge	Based on political pressure; Consultant 6 joined at very late stage due to contacts, partners had never worked together before; Research 2 was forced to stay in
	5	Capability-based motives to gain access to knowledge	
	8	Finance based motives to gain access to financing	Project tasks based on capabilities
	14	Marketing-based motives to gain visibility	There was political pressure to put University 2 on, previous involvement was with University 1
C – de-centralised with lacking management	3	Capability-based motives to gain access to knowledge	Based on the companies' capabilities to contribute to the project
	6	Capability-based motives to gain access to knowledge	previous experience with partner or personal recommendations from friends and colleague
	9	Capability-based motives to gain access to knowledge	Prior experience with each other, knowledge of partners' capabilities; technology much more complicated than they can do in-house
	11	Capability-based motives to gain access to knowledge	Invitation due to capabilities in the area

4.2 Network operation

The three patterns of alignment between centralised and de-centralised approaches from network formation also appeared in network operation. The first pattern – a well-aligned formation between centralised and de-centralised approaches – translated into a well-aligned network operation. The Project owner and manager of Project 10 (EM7) exemplified this with regard to open communication between partners: *“I think everybody is quite happy about the sharing of knowledge.”* Also the

partners' goals were well aligned in these projects as exemplified by project owner and manager of Project 1 (EM1): *"we all pull in the same direction."* However, even here issues arose in the network operations. For example, the Project owner and manager of Project 1 (EM1) described: *"they (Owner 1 and University 1) are used to this kind of project. So they know how it works and they worked seriously on the project. But [Designer 1] is a rather small company. (...) And it's rather limited what they put into the project. They have to do the project work on the side."* This demonstrates the importance of collaboration capabilities by the participating companies.

The second pattern – misalignment between centralised and de-centralised approaches in network formation – resulted in difficulties during network operations. Here the communication was often not open as described by Project participant (Research 2) for Project 4: *"Because we are competitors with [Consultant 6], we are not involved with a lot of the work because that would disclose a lot of things."* This was due to the set-up agreed at the beginning of the project as the Project participant continued their description: *"we had to define something that we call open room and closed room which means that they are doing a lot of things in closed rooms so we are not even invited. And a lot of information is lost."* In other words, misaligned and sometimes even contradictory goals between partners could create difficulties for open communication. Task interdependencies could also cause major frustration as explained by Project participant of Project 14 (Class 3): *"I am surprised at the lack of commitment in some partners. Then the other partners sit on their hands."* As a result, Classification society 3 decoupled their processes from their partner as the Project participant continued their descriptions: *"I will deliver what I [promised], and then you will take care of your part. So that indicates the situation in this project. It's not the*

best collaboration. And I think that basically if he (the project owner and manager) was not involved, it would be much better." This shows that misalignments between partner self-selection and political pressure in network formation created negative effects for network operations.

The third pattern – a predominant focus on de-centralised network formation – led to unconnected innovation activities during network operation. Here, a lack of leadership and directed management led to unconnected teams within the project. The project manager (Project 9, EM8) explained: *"We have two parts here: we have the technical part and we have the commercial part."* Despite attempts at open communication, knowledge flow was very limited because of the project set-up as the Project manager (Project 9, EM8) continued: *"We have made a share-point side. I must say that we have not used it so much."* Thus, the sole focus on de-centralised approach to network formation and operation led to a lack of integration of project partners and their innovation activities. Table 4 summarises the findings network operation.

Table 4: Results regarding the inter-organisational relationships (1 – very weak to 5 – very good) in network operation

Relationship pattern	Proj	Goal alignment		Open communication		Joint decision making	
		Mean value	Qualitative evaluation	Mean value	Qualitative evaluation	Mean value	Qualitative evaluation
A - Well-aligned	1	4	Good, some smaller issues with Designer 1	4,5	Good communication	4,5	are sticking to project plan
	7	4	Completely aligned goals, complementary competencies	4,5	Informal communication due to prior experience	4	residency principle, perfect team work
	10	3,33	No competing interests	4	Immediate sharing of data between all partners	3,33	Individual decision making with sharing of results
	12	3,6	Mutual interest, professional relationship	4,2	Open and frequent communication at project meetings	3,2	Joint decision making
	13	4	Mutual interests, complementary competencies, political decision to join	4	Business secrets because of customer-supplier relationship	3,5	Flexibility is constrained by roles of top management
B – misalignment between centralised and de-centralised	2	3,75	Solid alignment apart from a non-performing partner	3,75	Lack of engagement of a non-performing partner	3,25	Works well for those who are active in the project
	4	2,8	Different goals between Consultant 6 and owners on one side and Research 2 on the other side	3,8	Two communication rings: inner ring with Consultant 6 and owners, outer ring with Research 2	3,8	no
	5	3,6	Owners 4-6 have own agenda	4,2	Overall good but lack of project manager (University 4) to stimulate communication	4,4	Owners 4-6 do not exchange information
	8	4,29	Focus on research activities with little effort on project management	4,43	Little coordination coming from University 1 as the project owner and manager	3,57	Every project member decides for themselves
	14	4	Parallel work at University 2 and Class 3 with separate focus	3,5	No direct project-related communication	3,5	non existent
C – de-centralised with lacking management	3	4	Organised in sub-teams with dynamic design	4	Meetings twice a year, frequent communication in the sub-teams	3,4	Mostly central decision making by Project leader
	6	4	Unconnected sub teams within the project	4	Unconnected sub teams within the project	3	unconnected sub teams within the project
	9	4	Two parallel parts of the project: technical and commercial side	4,5	Very open communication with frequent meetings	3,5	Inclusive decision making with engineers
	11	3,75	Mistrust between EM10 and Owner 1 regarding the commercialisation of the developed product	4	Supplier-customer relationship. Concern about progress and business secrets.	3,25	Open dialogue

5. Discussion

Table 5 summarises the case findings and forms the basis for this discussion. Our findings showed three main patterns of dependencies between network formation and network operation. First, well-aligned processes of network formation resulted in well-functioning innovation projects during network operation (Pattern A). Here, the trade-offs between centralised and de-centralised processes were well aligned across both formation and operation. Second, misalignment between centralised and de-centralised approaches in network formation resulted in unconnected sub-activities during network operation (Pattern B). Here, innovation activities lacked integration and oftentimes were also not progressing at the required pace. Third, projects that focused on a de-centralised approach with missing leadership during network formation resulted in unconnected sub-activities during network operation (Pattern C). Here, innovation activities, while progressing at the desired pace, were lacking integration into a coherent innovation outcome and process. This section discusses these findings with respect to existing theory in the field.

Table 5: Overview of main case findings

Proj	Network formation	Network operation	Links between formation and operation
1	Self-selection of partners from prior experience; Political motives for joining	Good relationship between all partners	A - Well-aligned
2	Self-selection of partners based on capabilities; Political motives for joining to gain access to finance	Good, but a non-performing member spoils the relationship	B – misalignment between centralised and de-centralised
3	Self-selection of partners based on capabilities; Capability-based motives for joining	Sub-teams without close interaction	C – de-centralised with lacking management
4	Partner choice from political pressure in addition to self-selection;	Circles of relationships with exclusion of some partners	B – misalignment between centralised and de-centralised

Capability-based motives for joining			
5	Partner choice from political pressure in addition to self-selection; Capability-based motives for joining	Unconnected sub-activities	B – misalignment between centralised and de-centralised
6	Self-selection of partners from prior experience; Capability-based motives for joining	Unconnected sub teams	C – de-centralised with lacking management
7	Self-selection of partners from prior experience and from political pressure; Capability-based motives for joining	Good relationship between all partners	A - Well-aligned formation and operation
8	Political motives for joining to gain access to finance and visibility	Unconnected sub-activities	B – misalignment between centralised and de-centralised
9	Self-selection of partners based on prior experience and capabilities; Capability-based motives for joining	Two parallel and unconnected parts of project	C – de-centralised with lacking management
10	Self-selection of partners based on prior experience and capabilities; Political and capability-based motives for joining	Good relationship between all partners	A - Well-aligned formation and operation
11	Self-selection of partners based on capabilities; Capability-based motives for joining	Mistrust between partners based on competing interests	C – de-centralised with lacking management
12	Self-selection of partners from prior experience; Capability-based + political motives for joining	Good relationship between all partners	A - Well-aligned formation and operation
13	Self-selection of partners from prior experience; Capability-based and political motives for joining	Non-supportive partner's management hinders more open relationship	A - Well-aligned formation and operation
14	Partner choice solely from political pressure; Political motives for joining to gain visibility	No direct relational involvement between project partners	B – misalignment between centralised and de-centralised

Pattern A showed projects of the studied PFIN where the approaches to centralised and de-centralised network formation were well aligned with each other creating a good foundation for network operation where activities of a well-integrated innovation projects progressed smoothly (e.g. Projects 1, 7, 10, 12, and 13).

Centralised and de-centralised approaches to network formation focused on partner choice based on organisational capabilities and joint experience (Kalsaas 2013, Santa et al. 2014) led to well-managed network operations including open and frequent communication regarding the product development tasks (Dyer and Nobeoka 2000).

Specifically the perception of a joint goal by the project partners led to positive project governance and harmonious inter-organisational relationships (Aarikka-Stenroos and Sandberg 2012, Kreye 2017). These findings add to the literature on innovation networks by showing that aligned processes between centralised and de-centralised network formation and operation can lead to innovation success in PFINs.

Pattern B showed misalignment between centralised and de-centralised network formation resulting in systematic exclusion of project partners from (parts of) the innovation activities (e.g. Projects 2, 4, 8, and 14). Here, the partner selection was determined by central network management through political pressure to introduce and/or keep specific partners within the network. These centralised decisions were based on considerations of the legitimacy of the PFIN through the list of participating organisations, contrasting descriptions in the literature which has highlighted individual organisation's participation in an innovation network that legitimises its presence on the market sector (Sydow and Windeler 1998). In our case PFIN, innovation activities lacked integration and progression. In an extreme case (e.g. project 14), projects partners did not communicate with each other, stalling project progression all together. Our research thus contributes to the literature by showing how misaligned processes of centralised and de-centralised network formation create detrimental longitudinal effects in network operation in terms of progressing innovation activities.

Pattern C showed projects that were missing leadership and management in network formation, resulting in poorly integrated innovation projects in network operations (e.g. Projects 3, 5, 6, 9, and 11). These projects had a predominantly de-centralised approach to network formation where specifically prior connections

(Hagedoorn et al. 2006) were utilised for partner selection. However, these projects lacked aspects of leadership and management, resulting in separation in network operation where different sub-tasks were completed by different sub-teams without integration. Within these sub-teams relational approaches including open and frequent communication (Dyer and Nobeoka 2000) led to progression of the project activities as planned; however, without integration between them. This insight contributes to the literature by showing the potential negative consequences of focusing on de-centralised approaches for network formation and operation in PFINs.

6. Conclusions

This research links the formation and operation of publicly funded innovation networks (PFINs) by studying the alignment between processes of centralised and de-centralised innovation networks. The analysis of a PFIN in the Scandinavian maritime industry showed three patterns of inter-organisational relationships that crystallised during network formation and determined processes during network operation. Our research showed that PFINs require both centralised and de-centralised processes of network formation and operation. Missing centralised processes resulted in individual projects where innovation activities were progressing but lacked integration and alignment (Pattern B). Consequently, PFINs require alignment between partner self-selection and self-management as well as integration of innovation activities. The lack of this alignment was shown to result in stagnation of the innovation project (Pattern C). The ability to align both approaches (centralised and de-centralised) resulted in well progressing and performing innovation projects (Pattern A). This research thus contributes to the literature on operations management in complex networks

(Aarikka-Stenroos and Sandberg 2012, Michaelides et al. 2013, Shaw and Burgess 2013, Song et al. 2016), extending the on-going debate of innovation networks, linking network formation and operations with a specific focus on PFINs.

This research has multiple implications for practice. Despite the often medium-term set-up of PFINs to fulfil industry and political objectives, the consideration of the long-term industry networks and inter-organisational relationships between partners greatly affects the nature of operations in the PFIN. This gives great responsibilities to network managers in terms of utilising both de-centralised and centralised approaches during network formation and network operation and more importantly to align these approaches to facilitate innovation activities. Network managers are advised to enable and support the partner selection based on organisational competencies and joint experience as well as relational partner management of innovation activities (de-centralised approaches), while also guiding these activities through integration and leadership. However, this also gives great responsibilities to initiators of these PFINs, such as national and cross-national funding bodies, to align political objectives with bottom-up partner selection. For example, politically motivated partner selection does not necessarily hamper innovation activities in the PFIN if these partners are integrated within existing structures of project and network partners. In contrast, network initiators need to either abstain from partner selection decisions or integrate them into existing network structures and relationships through continued leadership and guided coordination. A central task of network managers as well as PFIN initiators is thus the alignment of centralised and de-centralised approaches from network formation and operation.

This research points towards important areas for further research in innovation networks based on limitations of this work. First, due to the exploratory nature of this research, some concepts emerged from the empirical analysis and require further integration into theory building. Specifically, the adverse relationship effects of political pressure in PFINs deserve further attention. This factor has not been studied sufficiently through empirical investigations in the innovation management literature. Second, this research employed a single-case study approach and is hence limited in terms of (statistical) generalisability). Investigating other cases in different industrial sectors would complement this research and help identify common factors for PFINs irrespective of industrial setting. This will further enable triangulating insights with the research presented in this paper and thus increase the generalisability and theory-building in this area. Third, a further limitation related to the single-case research arises from the temporal limitation of PFINS. Future research needs to assess the possible link between inter-organisational relationships (in previous innovation networks) and network formation in follow-up innovation networks. This research focuses the link within one innovation network; however, exploring the longitudinal effects would further enrich the literature on innovation networks.

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Appendix

Exemplar interview questions:

Formation:

Why did you choose to work with your project partners?

Operations

How would you describe the relationship in the project/work package since the start of BlueINNOship?

How would you describe the knowledge flow within your project/work package?

How does the operation compare to your expectations regarding working with your project/work package partners?

Survey questionnaire

Likert scale from “very important” to “not important” (1-5):

Why did your organization, in your opinion, join the [Case PFIN] partnership?

- Access to finance
- Access to knowledge
- Access capabilities we do not have in-house
- Access to potential customer (network member)
- Share the risk
- Decrease development cost
- Decrease development time
- Gain visibility in the industry and general public

Likert scale from “strongly agree” to “strongly disagree” (1-5):

- My innovation partners are, in my opinion, reliable, act responsible to my organisation’s needs and will fulfil the expectations placed in them.
- In my innovation network, we all have the same goals we want to achieve with this innovation project.
- In my innovation network, we communicate and share information regularly and openly with each other without worry about information leakage.
- In my innovation network, we always make strategic decisions jointly between all partners.