Partnerships for environmental technology development in the shipping industry: Two Danish case studies

Abstract

The shipping industry is confronted with stricter environmental regulations and societal pressure concerning its environmental performance. However, a command and control approach has not succeeded in facilitating the development of cleaner industries. With this goal, key public and private actors increasingly rely on partnerships and in Europe several partnerships have been created for the development of environmental technologies in the shipping industry. While the literature on partnerships with a focus on sustainability has contributed to a better conceptualization of the subject, a gap exists on the interactions of: firstly, institutions and actors in partnerships; and secondly, two or more initially independent partnerships. This paper aims to improve the understanding of how partnerships contribute to developing cleaner technologies in the Danish shipping industry by shedding light on the processes and the outcomes of two separated partnerships (Partnership for Cleaner Shipping and Green Ship of the Future) and the interactions of the two partnerships. In terms of processes, the partnerships are influenced by the participation, scope and division of roles among partners. In relation to outcomes, the first salient issue is that both partnerships have developed organizational forms which proved to overcome the tensions in traditional partnerships, between open and information-based networking on the one side and closed and development-oriented collaboration on the other side.

Keywords

Eco-innovation; partnerships; shipping; air pollution control; scrubbers; end-of-pipe; maritime industry; environmental technology; cleaner technologies; Denmark.

1 Introduction

Over the past 40 years, the nature of environmental concerns and their effect on policy-making have changed significantly (Rayner, 2006). In the 1970s, environmental problems were regarded as the unfortunate side effects of economic growth. Governments created environmental protection agencies and ministries that were given responsibility for setting pollution limits and, in some cases, cleaning up after limits were exceeded (Colby, 1991). In other words, environmental regulations focused on repairing and setting limits to harmful activity; end-of-pipe technologies, clean up strategies or business-as-usual plus a treatment plant

were regarded as appropriate in this respect (Smink, 2002). The regulatory approaches to dealing with environmental impacts of the international shipping industry originate from a "classical" paradigm addressing pollution by setting emission limits and suggesting the use of end-of-pipe technologies (e.g., scrubbers) and monitoring equipment.

From the mid-1980s, the dichotomy between economy and environment was challenged by concepts like sustainable development. Sustainable development has come to dominate the environment-development debate. As a key feature of the policy paradigm of sustainable development, the terms of debate have changed from traditional environmentalism, with its primary focus on environmental protection, to the notion of sustainability which requires much more complex processes of trading off social, economic, and environmental priorities (Carter, 2001). In other words, a strategy for sustainable development requires new forms of societal efforts; this will not be realistic within the traditional public environmental regulations as known in the 1970s and 1980s (Jänicke and Jörgens, 1998). During the 1980s and 1990s in land-based industries, public environmental regulations were increasingly supplemented with self-regulation and market-based regulation. In the shipping industry, however, until the late 1990s, only some major shipping firms were frontrunners in adopting environmental management systems (EMS) or embracing Corporate Social Responsibility strategies. These initiatives were motivated by major shipping accidents; i.e., Exxon Valdez, Prestige, Erika, and to a minor extent by the discourse on sustainable transport promoted by the United Nations (Comtois and Slack, 2007; Pawlik et al., 2012).

The increasing number of international regulations on shipping has forced shipping companies to look for technological and organizational means of addressing environmental impacts on air quality, seawater or climate. Across the European Union, shipping stakeholders join different types of partnerships for the purpose of developing maritime environmental technology. At the European level, partnerships have been funded by the European Commission as listed in the database SKEMA (SKEMA, 2015). At the national level, similar partnerships for maritime environmental technology have been established involving national partners (i.e., Low Carbon Shipping in the UK, Effship in Sweden, Partnership for Cleaner Shipping and Green Ship of the Future in Denmark). Despite this number of initiatives, few analyses and evaluations can be found in the literature regarding the processes and outcomes of partnerships as mechanisms for developing environmental technology in the shipping industry.

Partnerships is a new way to address environmental problems as cooperative environmental management regimes (Meadowcroft, 1999). This shift towards collaborative approaches can be seen as shift to a new dominant paradigm (von Malmborg, 2003). In the Earth Summit in Johannesburg in 2002, one of the conclusions was that partnerships should be a key mechanism for greening (Kolk et al., 2008). However, the conceptualization of partnership can take multiple forms and have multiple associated meanings (McQuaid,

2010). In this article, the focus is on partnerships as *"collaborative arrangements in which actors from two or more spheres of society (state, market and civil society) are involved in a non-hierarchical process, and through which these actors strive for a sustainability goal"* (van Huijstee et al., 2007, p. 77). Partnerships with a focus on sustainability can be studied in two perspectives: The institutional level concerns the partnership as a governance mechanism; the key issue here is the role that the partnership plays in a governance regime. The second level considers partnerships from an actor perspective; here the focus is on the partnership itself, rather than the partnership and its functions within the overall environmental governance regime (van Huijstee et al., 2007). Research on partnerships from an actor perspective seeks to improve the processes in the partnerships. Under this logic, partnerships are analysed in terms of advantages and disadvantages of partnering and with the aim to identify decisive success factors (van Huijstee et al., 2007).

In this article, we analyse the processes and the outcomes of two partnerships in the Danish shipping industry: Partnership for Cleaner Shipping and Green Ship of the Future. It is investigated how the agendas of public and private actors are aligned for the purpose of collaborating in the development of environmental technologies. The analysis focuses on these two partnerships once they are established, which allows researching on the processes and outcomes of partnerships. Since some actors participate in both partnerships, we will also investigate how these two partnerships interact.

This article is divided into six sections. The second section presents the analytical framework. The third section describes the methodological approach to acquiring information. The cases are presented in the fourth section, and in section five, we present the discussion. The last section is the conclusion and suggestions for further research.

2 Conceptual framework

The literature on partnerships is quite diverse. Various authors have used many different classifications of partnerships (see for example Linder (1999), Nelson and Zadek (2000), van Ham and Koppenjan (2001), Bäckstrand (2006), Lehmann (2006) and Glasbergen (2007) and McQuaid (2010)). McQuaid (2010), for example, refers to Snape and Stewart (1996) who distinguish between three ideal-typical forms of partnerships: facilitating partnerships, co-ordinating partnerships, and partnerships of implementation. According to Hutchinson and Campell (1998, p. 9) in McQuaid (2010), there is a consensus about a number of defining features: partnerships bring together a coalition of interests drawn from more than one sector to generate agreement; partnerships have common aims and a strategy to achieve these; partnerships share risks, resources and skills, and partnerships achieve mutual benefits and synergies. Partnerships can also be seen as networks for the greening of industry. These networks seek to bridge relations between public and private actors. The resulting relations can have several outputs as concrete projects, new forms of environmental

governance, or an enhanced capacity of the actors to deal with environmental issues (Lehmann, 2006). Linked with this approach to partnerships, Offermans and Glasbergen (2015) suggest that certain types of partnerships contribute to sustainability by producing knowledge. Furthermore, partnerships have been studies by a large diversity of disciplines. Van Huijstee et al. (van Huijstee et al., 2007, p. 76) observe two major perspectives in the partnership literature: the institutional perspective and the actor perspective (see also Table 1). In the introduction of this article, we have used the institutional perspective to describe in short the context in which partnerships have arisen, the role of partnerships in society, and the institutional implications of the partnership trend. However, in this article we do not question whether or not a partnership as such is a good instrument for implementing eco-innovations in the shipping industry. Instead, we look at partnerships as instruments for the advancement of actor-specific goals, which is the focus of the actor perspective (see also van Huijstee et al. (2007)).

[Insert Table 1 here]

In our point of view, the institutional perspective and the actor perspective are not two separate viewpoints, but two overlapping perspectives. For example, in order to understand the processes and the outcomes of partnerships, which according to Huijstee et al. (2007) is at the core of the actor perspective, we consider it important to analyse how partnerships contribute to facilitating solutions and to which extent partnerships promote learning in networks. Based on a literature study, Huijstee et al. (2007) refers to these latter two aspects as belonging to the institutional perspective.

Koppenjan (2005), on the other hand, makes a distinction between the formation process of partnerships and the partnerships once established. In this article, we consider the formation process as being important, but we focus on partnerships once functioning. With this in mind, we have adapted three characteristics of partnerships from van Ham and Koppenjan (2001) to understand how partnerships for eco-innovation can be organized: 1) Participation, 2) Scope of the activities, and 3) The division of roles between actors. These three elements have overlaps with the key success factors in partnerships as described by McQuaid (2000, 2010); hence, the resulting framework has inputs from the three sources.

Participation is about which actors participate and under which conditions (Van Ham and Koppenjan, 2001). We include two aspects to explain participation. The first aspect deals with trust between organizations and individuals in the partnerships. Participant organizations must count with an appropriate mix of skills and roles in order to maintain the participation over time (McQuaid, 2010). The second aspect concerns the capacity for cooperation and mutualism. In order to achieve the planned targets, the actors in the partnership must have a strong network of communication and work at the local level. In practice, the strong network gives the organizations flexibility and authority to share resources and make decisions (McQuaid, 2010).

The second aspect of importance to the analysis of functioning partnerships for eco-innovation is the *scope of the activities*. Partnerships for the greening of industry through eco-innovations are organized around two types of activities: collaborative projects and learning systems. Projects are limited in time, with a small number of partners. Learning systems require more commitment from the partners and the focus is on longer time frames (Lehmann, 2006).

Once the partners have defined the scope of activities, they need to define their own *roles.* This does not mean that the partners must be allotted a small set of actions, but they need to clarify in which ways each partner is involved in the partnership and how they handle this involvement. Van Ham and Koppenjan (2001) propose a series of guiding roles for public and private partners. According to these, public partners are responsible for coordinating with politicians, safeguarding public interests, knowing the market orientation, providing funding, and giving guidelines on the social impact of the project. Private partners, on the other hand, are in charge of project management, involving private parties, taking care of project specifications, and sharing otherwise confidential information which is relevant for developing new products.

3 Methods

This study has been carried out as part of the Interreg IV B project SAIL (Sustainable Approaches and Innovative Liaisons), which runs between 2012 and 2015 with 17 partners from the Netherlands, Germany, Belgium, France, the UK and Denmark. One of the goals of the project is to promote the creation of public-private partnerships which serve as platforms for the experimental adoption of hybrid sailing prototypes, i.e., wind propulsion (SAIL, 2014). The purpose of this article is to provide insights into how a public-private partnership can be organized to facilitate processes that contribute to the desired outcome, i.e., the adoption of hybrid sailing technologies in the shipping industry. The logic of relying on the case study as an inquiry strategy is the possibility to translate the insights from one context into another under the given criteria (Flyvbjerg, 2011). In this section, the authors explain the logic of the case selection and present how the empirical data was gathered and analysed.

3.1 Selection of the partnerships

In recent years, the Danish actors in the maritime industry have formed several partnerships for branch innovation. However, not all of these partnerships have a focus on environmental technology development and adoption. A criterion for selecting the partnerships for this analysis was that the partnerships should have an explicit goal of developing environmental technology. The two cases presented in this article are the two most representative Danish public-private partnerships formed with this purpose. Our strategy has been to

describe and capture key issues to discover any common pattern between them. The lessons learned from our cases are assumed to be informative about the experiences of similar cases elsewhere.

3.2 Data collection and analysis

The empirical evidence was collected by triangulating four qualitative methods: literature review, documentation analysis, interviews, and observation. The literature review provided the concepts as presented in Section 2. As a first step, we analysed documentation related to both partnerships; generally the documents were publically available on the websites of both partnerships. After the interviews, we complemented this review with documentation provided by the interviewees, such as project descriptions, minutes of meetings, yearly plans, and partnership contracts.

The first part of the documentation review helped us to identify eight interviewees (Appendix 1). As the most important criterion, the interviewees were required to be acquainted with the characteristics of the partnerships and their socio-technical context. Four interviews were carried out with actors who had actually initiated the partnerships or had secretary functions (1, 2, 3 and 6). Two interviews were carried out with representatives of companies that developed projects within the partnerships (5, 7 and 8) and one interviewee provided insights into the context conditions within the sector (4). A semi-structured interview guide was used in these interviews (Appendix 2). The initial questions had the purpose of gathering general information on the drivers behind the actors' involvement in the partnership. The following questions helped to assess the organization and mechanisms of interaction within the partnerships. These interviews were audio recorded and transcribed. To analyse the interviews, we combined deductive and inductive coding techniques which allowed us to "extract" relevant information from the interviews (Saldaña, 2009). In the early phases of the analysis of the data set, we used hypothesis coding (Saldaña, 2009, p. 122). Thus, we generated a predetermined list of codes based on our literature review. These codes regarded the type of evidence that we expected would emerge from the dataset (Table 2). We also used "InVivo", an inductive coding technique which has the purpose to highlight the striking phases of the interviewees. These phrases could reveal underlying assumptions and explanations concerning a given issue (Table 2) when new insights emerged from the transcripts that we had not accounted in our hypothesis coding. When coding the data, the authors had access to a complete list of hypothesis codes and the InVivo codes were added as they appeared. The authors used the software QSR NVIVO to manage the list of codes and save the coded transcripts.

[Insert Table 2 here]

After coding the interview transcripts, the authors grouped the patterns emerging from both types of codes into themes (Miles et al., 2013). These themes were of three types: the characteristics of the partnerships

(i.e., activities, organization, definition of roles, and projects); the actors (i.e., drivers) and the interaction between partnerships (i.e., outcomes, processes). Quotes from interviewees were used according to these themes and formed the basis for the case study and the reflections of the authors.

During the data collection phase, the main author of this article was a research fellow at the Maritime Centre for Operations and Development (MARCOD, Denmark). MARCOD is an intermediary organization, which collaborates with Danish maritime stakeholders by organizing seminars on environmental technology and advising small and medium-sized companies on how to enter into the market of environmental services and technologies. When collecting the data, the main author participated as an observer in a number of meetings of the Green Ship of the Future partnership. This interaction with maritime stakeholders was important to understand discourses vis-à-vis environmental regulations –not explicitly stated in public documentation. The meetings included technical presentations and round-table talks. In these round-table talks, the representatives of different organizations shared ideas and presented the progress of their respective projects.

4 Two Danish partnerships for marine environmental technology

The Danish maritime industry is represented by all actors in the shipping value chain: shipowners, equipment manufacturers and suppliers, logistic firms and advanced service providers, banking, R&D, insurance and law. The Danish government and Danish-based global incumbent shipping firms have actively participated in the creation of a national blue cluster which groups these different actors into a collaborative innovation system (Sornn-Friese, 2007; Danish Government, 2012). A leading role has been taken by the Ministry of the Environment, which actively promotes partnerships for environmental innovation. "In the future, the global market will increasingly demand more eco-efficient technological solutions, and Danish firms, knowledge institutions and authorities together hold many of the competencies required to develop these technologies" (Danish EPA, 2014). Therefore, it is advantageous to bring together different competences in strategic partnerships (Danish EPA, 2014). In this section, we focus on the role of two Danish partnerships in promoting environmental technology in the shipping industry.

4.1 Partnership for Cleaner Shipping

The Partnership for Cleaner Shipping is a public-private partnership between the Danish Environmental Protection Agency (EPA) and The Danish Shipowners' Association. This partnership seeks innovative solutions to reduce air pollution from ships in a cost-efficient way, while generating green innovation from equipment suppliers through spillover effects. The main objective of the Partnership for Cleaner Shipping is to develop and diffuse technology to comply with air pollution regulations included in Annex VI of the International

Convention for Prevention of Pollution from Ships (MARPOL) by the International Maritime Organization (IMO). Some of the objectives of the partnership are (Danish EPA, 2010):

- Focusing attention on the importance of reducing air pollution from shipping by promoting awareness of the new regulations passed by the International Maritime Organization (IMO)
- Ensuring the visibility of these measures
- Promoting innovative frameworks for environmental/technological development to meet the regulatory requirements

The Partnership is directed by a steering committee. The steering committee has representatives from the Danish EPA and the Danish Shipowners' Association. The steering committee organizes regular meetings as part of the Partnership. The meetings have the purpose of deciding which project proposals to endorse and on this basis the Partnership can apply for possible funding by the Environmental Ministry. In relation to the Danish EPA, the Partnership is required to define technical solutions under existing regulations. Furthermore, the Partnership is used as a testing ground for new regulations, which may ultimately be incorporated into public environmental regulations.

Another purpose of the meetings in the Partnership is to organize activities to facilitate knowledge circulation in the maritime branch. The Partnership also organizes workshops, sometimes in collaboration with external organizations. For example, a conference organized in November 2011 targeted shipowners and equipment manufacturers to create a forum in which they could meet and present some of their solutions (Interview 1). In line with this knowledge creation, the first initiative carried out by the Partnership was to commission a research report on the environmental impact of shipping on the air quality around Danish waters. The study showed the location of the most impacted areas with air pollution and also suggested some scenarios for the future based on solutions to the problems (Interview 3).

The Partnership also has a reference group. This group does not make decisions on fund allocation but feeds political and technical discussions. Some of the companies within the reference group are free to prepare projects and request funds from the partnership.

4.2 Partnership Green Ship of the Future

Green Ship of the Future (GSF) is a privately initiated partnership involving around 40 Danish marine equipment and service providers and major shipping firms and public-private organizations. The Partnership was initiated in early 2008 for the purpose of finding technical solutions to air pollutant emissions in new vessels - particularly CO_2, NO_x and SO_x. To find possible ways to reduce these emissions, the partners com-

missioned a set of technical studies. The first study had a container vessel as reference; the second had a bulk carrier vessel as reference, and a third study had the purpose of finding technical solutions for the retrofitting of existing vessels to comply with the MARPOL Annex VI requirements for SO_x (Schack, 2009). After these analyses, the Partnership has broadened the scope of activities to partner projects, topic-based groups, and "project bubbles".

Different types of partners are involved in Green Ship of the Future: classification societies, consultants, equipment suppliers, service providers, and shipowners. Shipping and equipment firms play a central role in the Partnership. Ten equipment suppliers are members of the Partnership and their technologies and competences cover a wide area of products and services, including engine, ballast water management systems, pumps, instrumentation, and refrigeration. The Partnership includes eight large shipping firms.

In addition to the private firms, branch organizations and some government agencies are network partners: Danish Maritime Authority, Danish Shipowners' Association, Danish Maritime, and Danish Marine Group. There is also a group of associated partners, such as universities, professional schools, and the media. These academic and training partners provide the research experience and materials to perform some of the partner projects in GSF. The media partner is the industry magazine "Shipping" (Søfart).

4.3 Interaction inside and between the two partnerships

In this part, we analyse the development and the dynamics of the two partnerships. We focus on the scope, participation, and division of roles in order to better understand the collaborative characteristics of this new form of interaction at an institutional and actor level/perspective. Subsequently, we analyse how partnerships interact and in this way improve their impact.

4.3.1 Partnership for Cleaner Shipping: New ways of organising the dialogue between policy and business

The Partnership of Cleaner Shipping facilitated the development of environmental technologies by allowing private stakeholders to meet in common projects in which they could match complementarities. The partnership supported the project ideas by delivering a subvention with funds from the Ministry of Environment as shown in Table 3.

[Insert Table 3 here]

In the literature of partnerships for sustainability, there is a focus on the economic aspects of infrastructure building, but our study shows that the main benefits of the public-private partnership are related to the interaction between the business and the regulative authorities and more specifically between technical and regu-

latory issues. The collaboration in and around the projects gives firms and other actors a unique possibility to contribute to the political agenda, as in the projects in which one of the partner firms (large marine engine manufacturer) has been involved. The process characteristics of the Partnership for Cleaner Shipping are illustrated in Table 4.

[Insert **Table 4** here]

For example, a marine engine manufacturer participated in two projects which were supported by the Partnership. As shown in Table 1, the engine manufacturer benefited from the Partnership's support in developing maritime engines with low NO_x emissions. The Partnership helped to find a subvention of around 35% of the project's total cost. The project gave the firm a possibility to contribute to the political regulatory agenda:

> "When collaborating with the regulators in this project, we did not ask for inputs on the technical aspects, but on legal matters, on how to include technical details when proposing a new regulation, which was part of the project. We don't ask the State for input on how to develop an engine, but instead on how to make a regulation for this, and we made some papers together. We submitted it to the Partnership steering group, the shipowners had some comments, and then we agreed on how this IMO paper should look like. Then we submitted it to IMO, we contacted the Danish delegation when this was discussed in the IMO, and then regulation came out of this" (Interview 5)

The engine manufacturer's involvement in the Partnership started through networking with the Danish EPA. The new regulations set by the IMO were on the firm's agenda, but retrofitting old engines with NO_x-reducing technology was not as high a priority as developing new engines. However, the external funding and networking were seen by the top management as an opportunity to gather new ideas from shipowners and to influence policymaking:

> "This project started due to the regulation controlled by the IMO on air pollution by ships. We participated in these meetings in the Danish delegation. There was a lot of work; actually, in the way regulation happens. Nobody knows about big engines from the regulatory side, so you have a lot of communication with the State administration, shipowners and suppliers on what is [technically] possible before the regulation. In 2008, it was decided that this kind of regulation was going to be implemented but it was not finalized. We are lucky to have some of the most progressive shipowners here in Denmark, so we could push for greener technologies. This is how this project started, because of lots of things like regulatory contacts and consumers and suppliers" (Interview 5).

As mentioned in section 4.1, the partnership for Cleaner Shipping is used as a testing ground for new regulation: "Obviously, we need technical solutions for both, the regulation we have agreed upon and also to form the basis of our new future regulation" (interview 2). For the Danish Shipowners' Association, the creation of a close relation with equipment manufacturers and with the government involves advantages for the association; thus, to "be part of the development, feed in the process [of technology development] and be aware of everything that is going on [in international environmental policy negotiations]" (interview 2).

From a traditional, technological perspective, low NO_x emission engines are unconventional. A change of paradigm started due to a combination of market and regulatory pressures. The design of NO_x reduction engines dates back to the 1980s, when the marine engine manufacturer's truck engines branch developed Selective Catalyst Reduction (SCR) systems in response to the 1985 US-EPA stringent standards for emissions of NO_x from heavy-duty engines and of PM from heavy-duty diesel powered trucks and buses. Similarly, certain shipowners wish to reduce their operational environmental impacts:

> "Previously, the success criterion for making good engines was having high NO_x emissions, because then you had good combustion and less fuel consumption; the turning point was the regulations or the business to business customers [shipping lines] who started asking for alternatives. These customers approach us, before the emissions regulations are implemented, to design engines with lower emissions. Our customers serve large cargo owners, like Walmart, IKEA, which require shipping lines to document their environmental impacts. …They want to have a green image, and there are also customers driving this. I think they [cargo owners] believe that they cannot survive without a good environment" (Interview 5).

A further advantage of this collaboration with State actors and shipowners was related to a communicational perspective. The collaboration made it possible for engine designers and manufacturers to work with the customers from the early stages of product development, making the communication with the shipowners in relation to the product development easier.

4.3.2 Partnership Green Ship of the Future: New collaborative forms of interaction in shipping

A milestone for the Partnership was the International Climate Change Conference (COP15) in Copenhagen (2009). COP15 was seen as an important arena in terms of future environmental regulation. It was important to produce technical studies which could influence the regulatory visions and give the shipping industry a more positive role:

> "Back in 2009, the shipowners were under scrutiny because the general perception in society was that they were not doing enough for the environment. It was clear that something needed to be done about the negative publicity, but also the negative publicity came from shipowners and the industry because it was not doing enough to be green. Then at the end of 2009 was COP15. COP15 was the main driver of the low emission studies—the container ships and the one on bulk carrier. They had to be finished and ready for COP15 in order to show the world that shipping was actually doing something. COP15 was also good marketing for the project" (Interview 6).

After the COP 15 experience, the goal is now more focused on how partners can develop and test solutions through project development and communicate these externally. Formal discussions take place at four general meetings each year. In addition, technical presentations are organized during these meetings:

> "What we have done now is to change the structure. We have technical presentations. We have either outside companies or partner companies come and discuss something important for the group or give

> presentations on a technical area, always on technical matters. Then, after lunch, we have topic-based groups" (Interview 6).

The main driver of interactions among partners is common business interest. Project partners join together in topic-based groups and prepare common projects (partner projects), which are subsequently presented as either prototypes or reports. So far, the topic-based groups are: novel ship design, on board systems/systems integration, and alternative fuels:

> "The new thing is having topic-based groups together with the project bubbles. If you have an idea, and if you want to discuss it with others, you can set up the bubble. We are not ready to make everything formal, we only have an idea, but you are welcome to join the discussion if you like. There is no promised outcome. It can be anything, the ideas people talk about. Then we have the topic-based groups in which companies choose which group they want to be with" (Interview 6).

These topic-based groups have organized 20 projects (13 related to machinery improvement, 5 related to operation and two for propulsion). Most of the projects in machinery improvement seek to improve the combustion process. In this way, pollutants such as NO_x can be reduced. Projects in the area of operation seek to reduce fuel consumption and thus reduce the emissions of CO_2 and SO_x.

The alliances within each project implied different kinds of resources by partners: man-hours, research infrastructure, and equipment testing. The outcome of the project was usually a research report that was publically shared through the GSF website, presented at a conference, or shared as a summary in industry magazines or specialized journals. Not all the designs reported were finally manufactured and installed: "Unfortunately, so, I don't think the whole packages of initiatives you have in GSF are implemented, part of it is implemented in a number of different vessels" (Interview 7).

GSF partners use a website to share promotional notes about their products or services; this was evident in six articles. Similarly, GSF also communicates the concept of "Green ship" with the industry through oral presentations at industry events and written summaries in industry magazines. To a minor extent, technical reports and summaries are also used as a communication strategy by GSF. Examples show, however, that the communication addresses the broad audience of the maritime industry in general (e.g., shipowners, cargo owners, manufacturers, ports). At least three communication elements were directed at shipowners. Several communication events targeted single stakeholders (like market, policy makers or NGO). Interestingly, these examples highlight the condition that the GSF has a commercial purpose with its communication strategy (rather than political). The process characteristics of the GSF are illustrated in Table 5.

[Insert Table 5 here]

4.3.3 Interaction between partnerships

In sections 4.1 and 4.2, we have described the two partnerships. In section 4.3.1 and 4.3.2, we have analysed these two partnerships separately. As stated above, since some actors participate in both partnerships, we will in this section analyse the interactions between both partnerships, by means of an example.

Both partnerships are important in their roles of co-creation of environmental technology and regulation but in different ways. This importance can also be seen by the way in which the two different types of partnerships supplement and complement each other.

Permeable boundaries between the partnerships and their context allow overlaps between the two partnerships. This part discusses how the two partnerships can interact through an illustrative example: the "scrubber development" project. Initially, the GSF Partnership funded a study to assess the emissions from a tanker vessel. The study also suggested alternative means of compliance with the sulphur emissions limits as stated in MARPOL. A technical feasibility study was carried out of two of these alternatives: a scrubber or LNG fuel:

> "Funding was provided by the Danish environmental authority [Through the Partnership for cleaner shipping]. Green Ship of the Future was carried out before the scrubber project, I don't think the scrubber was installed but it was designed as part of the Green Ship of the Future project" (Interview 7).

After this feasibility study, a smaller group joined the work on the scrubber: Alfa-Laval-Aalborg, a marine equipment manufacturer; the previously introduced MAN Diesel, and DFDS, an incumbent shipping firm operating in short shipping routes in the North Sea and the Baltic. The three firms had different drivers of developing an exhaust gas cleaning system to reduce sulphur emissions. For the marine equipment manufacturer firm, desulfurizing flue gas was a well-known procedure in other applications (Interview 8). The firm perceived it as a business niche to adapt a wet scrubber into a vessel (Knudsen, 2011). MAN Diesel & Turbo was involved to provide technical support to the connections between the main engine and the scrubber. The installation and tests were performed on a DFDS vessel. This shipping firm was interested in finding a cost-effective alternative to low sulphur fuels when navigating in SECA waters. For the manufacturer and engine provider, it was of great value to have access to operational data over time. The shipowner shared the operational data with the other partners: "with the partnership, shipowners provide lots of data that they wouldn't normally provide, they know it is not going to be misused" (Interview 6).

In addition to the three previous partners, classification societies provided inputs along the process. Some of them were consulted at different stages of the scrubber development:

> "Typically you involve one classification society for a specific project; then you start involving more classification societies. Obviously some of them have their own specific areas, so you cannot say it is the same set of rules, but kind of similar set of rules. Classification societies usually focus on security, reliability and similar. They focus on the safety of the vessel, that the piece of equipment doesn't threaten safety" (Interview 7).

The implementation phase was partly funded through the Partnership for Cleaner Shipping. This phase involved mainly meetings and technical communications. During these meetings, the discussions turned around funding and installations, with some of the partners willing to cover some of their costs themselves – i.e., the equipment manufacturer covers the installation costs (Interview 8). Other interactions also took place at this stage:

> "Of course, lots of discussions on who should pay for what; even though the project was partly funded, the participants also had to fund significant amounts. Part of the costs dealt with planning and interactions on how to deal with the installation of large pieces of equipment. There was also a lot of planning with the other partner MAN, because you had a standard engine, you did some modifications for the exhaust system, and we had to think how that effected the engine performances, which requirements should be put" (Interview 7).

The scrubber was finally in operation in 2010; the shipowner keeps record of the performance and the manufacturer uses the data to improve the design. Similarly, the operation of a wet-scrubber has helped to spot issues contributing to technical debates at a regulatory level, i.e., the measurement of scrubber wastewater parameters. A follow-up project is currently been developed by the partners for the purpose of integrating a scrubber technology able to eliminate NO_x emissions along with SO_x. The project is likely to receive support from the Partnership for Cleaner Shipping (Interview 8).

5 Discussion

In this article, we have analysed how the agendas of public and private actors are aligned for the purpose of collaborating in the development of environmental technologies. In this section, we will discuss our findings in relation to the literature, to theory and to practice. Since we found few contributions in existing literature on the processes and outcomes of partnerships as mechanisms for developing environmental technology in the shipping industry, we have analysed two existing Danish partnerships: the Partnership for Sustainable Shipping and the Green Ship of the Future partnership.

The *Partnership for Cleaner Shipping* is a typical public-private partnership which started as a public initiative managed by the Danish Environmental Protection Agency (Danish EPA). The main driver of its launching was to support cost-effective technology to enable shipowners to comply with international regulations on air quality. This partnership has succeeded in creating a platform for close collaboration between different actors in the maritime sector in developing and testing projects.

As described in the conceptual framework, ***participation*** is about which actors participate and under which conditions (Van Ham and Koppenjan, 2001). In the Partnership for Cleaner Shipping, there is an appropriate division of skills and roles between the actors in the partnership. In the first place, the Danish government has more than 20 years of experience in managing public subsidy programmes aiming at improving environmental technology development (Georg et al., 1992; Danish EPA, 2007). The Partnership for Cleaner Shipping is linked to the eco-innovation programme set by the Danish EPA. In the second place, Danish EPA relies on the "new" role of environmental authorities vis-à-vis polluting industries. In this new role, environmental authorities become active facilitators of industrial self-regulation. This is an important contribution to the institutional perspective when analysing partnerships, as described earlier. At least in a Danish context, partnerships have proven to be a good way to implement eco-innovations in industry. Eco-innovation comprises partnerships with several industries and not only with shipping. From the logic of the previous Danish EPA programmes, a publicly sponsored partnership programme seems to be necessary to create collaboration between users (shipowners) and suppliers (equipment manufacturers) and to enable these actors to develop environmental technology (Danish EPA, 2007, 2010, 2014). For private actors, it has also been important to participate in the partnership in order to get input on – for example – legal matters, on how to include technical details when proposing new regulation.

In that sense, the ***scope of the activities*** has not only been collaborative projects on technology development, but also to a great extent learning systems with the aim to improve the capabilities of the actors. The Partnership for Cleaner Shipping has been used as a collaborative platform for combining and gathering new ideas and influencing policy-making. There has been a development of ***roles*** of the public and private actors and the way in which they have been able to integrate and combine these. We can see a clear division of roles between the actors in the partnership, but also how actors have changed their traditional role and the way in which they (used to) collaborate. For example, private actors now have more focus on how to influence regulation, and the government has tried to a larger extent to influence technology development.

Green Ship of the Future is a business-to-business partnership, which started as an initiative by a group of shipowners and their suppliers. ***Participation*** in this partnership has been especially helpful for the actors involved in terms of securing that the regulations became based on knowledge of technological practice and not just theoretical paperwork. In other words, producing knowledge has been an important aspect of this Partnership. This has been done by means of producing technical studies in order to influence regulatory visions and give the shipping industry a more positive role. The COP15 in Copenhagen (2009) has been a main driver of these studies. After the COP15, the ***scope of the activities*** in the Partnership has changed from an advocacy oriented framework to an innovation and learning based partnership. The goal of the Partnership is now focused on how partners can develop and test solutions through project development and communi-

cate these externally. The main driver of interactions among partners is a common business interest. Within the Green Ship of the Future Partnership, partners work together on different projects (e.g., the air resistance of ships and a high efficient nozzle). Alliances within each project imply different kinds of resources from the partners: man-hours, research infrastructure and/or equipment testing. In other words, the actors have retained their traditional *role* in this Partnership. The outcome of the projects are research reports, publically shared through the Green Ship of the Future website, presented at conferences, shared as a summary in industry magazines or specialised journals. To a minor extent, technical reports are used as a means of communication by the Partnership. The communication strategy has a commercial purpose rather than a political purpose. The Green Ship of the Future Partnership is a good example of a partnership that has been organised around collaborative projects. As argued by van Ham and Koppenjan (2001), these projects are limited in time and with a small number of partners.

The initially separated partnerships do have interactions through projects. For example in a project on exhaust gas scrubbers, the Green Ship of the Future Partnership allowed partners to meet and plan the project. Partners co-funded feasibility studies and later the Partnership for Cleaner Shipping provided a grant to cover expenses linked to the installation of the system. An explanation for these interactions through a project is the individual interest of each of the partners involved in the project. Some partners explained that part of their interest when involved in the partnerships was to collaborate closely with the users of their products. This user-producer interaction becomes important in the shipping industry in general and in the development and diffusion of environmental technologies in particular. The participation in different partnerships provides an enhanced playground to test these technologies, while it becomes easier to bridge the user-producer relationships.

Innovative learning through interaction between users and suppliers has largely been studied in the literature of innovation. Aside other drivers, the most important is to improve product designs to tailor the needs of the users (Georg et al., 1992). According to Kemp and Volpi (2008), adopters of new complex technologies need time to familiarize with these technologies. That is why the activities and the support of consultants become key elements to support this process of familiarization.

6 Conclusions

This article contributes to the literature by reflecting on the processes and the outcomes of partnerships established with the initial goal to develop environmental technology. In terms of processes, the partnerships are influenced by participation, scope and the division of roles among partners. Previous research on partnerships for sustainability highlights the perspectives of institutions and actors in relation to partnerships. However, taking a look into the processes from the three aspects mentioned above reveals that the differences

between the perspectives become blurred as analysed in the discussion section. Therefore, rather than two levels of analysis on partnerships, the institutional and actor perspectives can be seen as complementary aspects which influence each other. Further research could test this framework in different national and industrial contexts. In particular, longitudinal case studies which also take into consideration the formation process of partnerships could supplement the study of the implemented cases presented here.

In relation to outcomes, the first salient issue is that both partnerships analysed have developed organizational forms, which have overcome the tension in traditional partnerships between open and information-based networking on the one side and closed and development-oriented collaboration on the other side. The partnerships have organized conferences and made public reports on environmental issues and solutions to create platforms of openness and awareness. To create platforms for innovation, the partnerships have a collaborative function between suppliers and end-users in the initial stages of developing new environmental technologies. This collaboration can take several forms, from forming affinity groups of suppliers interested in similar topics, to funding ideas that the group of firms have developed on their own. An understudied issue in the literature is how initially separated partnerships with similar goals interact. The study shows that partnerships create space for user-producer interaction, but these collaborative spaces are of limited scope, resources and time. By combining the collaborations across partnerships, it is possible to create a space for more complex projects like those focused on developing eco-innovations. Our suggestion for future research is to focus on how partnerships and/or the interaction between partnerships contribute to a more active role of the actors involved. In-depth case studies of organizations participating in two or more partnerships, could provide a comprehensive perspective on how the different partnerships benefit the participant firms and vice-versa.

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Appendix A

List of interviews by date, organization, stakeholder type and location

#	Date	Organization	Stakeholder	Duration of the interview (minutes)	Purpose	Location
1	07-12-2011	Danish Environmental Protection Agency: Environmental technology		43	The interviewee is responsible for the Danish Environmental Protection Agency in the eco-efficient technology promotion partnerships.	Copenhagen
2	23-01-2012	Danish Environmental Protection Agency: Eco-innovation project shipping		51	The interviewee is the Danish Environmental Protection Agency responsible for the Partnership for cleaner shipping.	Copenhagen
3	23-01-2012		Shipowners' Association	62	Responsible person for the partnership for cleaner shipping in the Danish shipowners' association	Copenhagen
4	10-02-2012	Danish Maritime Authority		27	Interview with responsible for cleaner technology development in relation to harbours	Copenhagen
5	15-10-2012	Maritime engines manufacturer	Equipment manufacturer	43	Global leader in marine diesel engines design and manufacture; involved in both partnerships	Copenhagen
6	15-10-2012	Green Ship of the Future	Public-private partnership	40	Coordinator of the Green Ship of the Future partnership.	Copenhagen
7	16-10-2012	Maritime equipment manufacturer involved in both partnerships	Equipment manufacturer	27	Global leader in maritime equipment supply; involved in both partnerships.	Aalborg
8	11-12-2013	Idem as 7 (follow-up interview)	Idem. as 7	40	Idem. as 7	Idem. as 7

Appendix B

Semi-structured interview guide; an example with private firm

1) Firm sustainability strategy and involvement in the Partnership

2) How the network became a network

a. How was the network established?

b. What was the aim of the network and how has it evolved over time

3) How the network functions/ functioned?

4) Possibilities of diffusion of these technologies in the future

Tables

Table 1 Perspectives in the partnership literature (based on van Huijstee et al. (2007))

Institutional perspective	Actor perspective
• Role of partnerships in (global) environmental governance regimes • The context in which partnerships arise: driving forces behind the partnership trend • The (potential) role of partnerships • Institutional implications of the partnership trend	• Partnerships as strategic devices • Advantages of intersectoral partnering • Risks of intersectoral partnering • Factors for successful intersectoral partnering

Table 2 Condensed list of codes used in the analysis of interview transcripts. The complete list of codes (hypothesis and In Vivo) is 91 items, the list included here is provided for explanatory purposes

Hypothesis codes	Description	In Vivo Codes	Description
Partnership_sustainability	Explains what defines the goals of sustainability in the partnership.	PCS_driver	Drivers related to the initiation of Partnership for Cleaner Shipping
Partnership_formation	Describes the beginning of the partnership, which actor(s) took the leadership and which goals this actor had.	PCS_organization	How the actors organized within the Partnership for Cleaner shipping, i.e. meetings, roles
Partnership_driver_govt	Addresses the drivers of the government when participating in the partnership.	PCS_dynamics_activities	Which activities and projects did partners carried in the Partnership for Cleaner Shipping.
Partnership_driver_private	Explains the driver of private actors when participating in the partnership	GSF_project bubbles	How actors intereacted in the Partnership Green Ship of the Future, i.e. project bubbles.

Table 3 Projects supported by the Partnership for Cleaner Shipping (Danish Shipowners' Association, 2011)

Project name	Partners	Objective
NO_x reduction/low NO_x ventilation motor	MAN Diesel & Turbo	10-20 % reduction in NO_x emissions. 25-50% PM reduction
Reduction of SO_x emissions/ development of a scrubber	Alfa-Laval Aalborg DFDS MAN Diesel	Development, installation and testing of a scrubber on a DFDS Ro-Ro vessel
Selective Catalyst Reduction (SCR) system/auxiliary engine	CATCON/ Haldor Topsøe/ Bornholmtrafikken	Adapting a SCR system to a vessel. Technical inspiration from the car industry
Development and standardization of a SCR system for vessels	RM Staal	
Development of PM filter for vessel engines	Teknologisk Institut Dinex A/S Ærøfærgerne A/S	

Table 4 Four main elements of the Partnership for Cleaner Shipping according to the conceptual framework

Participation	Scope	Division of roles
• Danish EPA • Danish Shipowners' Association	• Environmental technology development and diffusion to comply with IMO and EU regulations	• Danish EPA provides legal support and funds for projects • Danish Shipowners' Association promotes compliance with the regulations and project proposals

Table 5 Four main elements of the Partnership Green Ship of the Future according to the conceptual framework

Participation	Scope	Division of roles
• 40 partners carrying out different activities in the shipping industry (i.e., shipping firms, equipment suppliers, classification societies) • In addition network partners (universities, professional schools, professional media, branch organizations).	• Desk studies (ship design) • Early stages of project development in networks	• FORCE technology: Coordination of the partnership • Partners: pay membership fee and participate actively in meetings and activities