The function of intermediaries in collaborative innovation processes: Retrofitting a Danish small island ferry with green technology

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Abstract

Intermediaries are actors who perform several functions during innovation processes such as brokering and networking. In this article, the aim is to analyse how intermediaries support collaborative innovation processes taking place in green maritime technology projects. In particular, retrofit projects related to cleaner technologies and small vessels are an understudied subject. The case study of a Danish small island ferry retrofit shows that intermediaries are important to stage the collaboration between actors. They can provide functions to the incipient network as foresight, brokering, increasing network connectivity, and scanning of information. However, intermediaries can also have a proactive role in shaping the emerging innovation pathways. In this case study, intermediaries negotiate each partner's role and define the goals of the project. The results contribute to the broader eco-innovation literature by analysing intermediation in innovation in a process perspective.

Keywords: Innovation intermediaries; Intermediation; eco-innovation; demonstration projects; Collaboration; Green maritime technology; Ferry; Denmark

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1 Introduction

Shipping is estimated to account for 3.1% of the global CO_2 emissions (as an average of 2007-2012) and due to the growth in shipping, this is forecasted to increase by 50-250% by 2050. However, an analysis of Buhaug et al. (2009) shows that a 25-75% improvement in CO_2 efficiency in shipping is reachable with known measures mainly directed towards energy efficiency. Emission reductions of more than 33% could be achievable by 2030 at a negative or zero marginal cost (Eide et al., 2009). In general, the innovation of cleaner technology in the maritime sector requires the involvement of a number of stakeholders (Mosgaard et al., 2014b). The introduction of cleaner technologies can be complex and history shows that it may carry difficulties, especially concerning retrofit solutions that influence the operation of the vessel. There seems to be resistance to implementing cleaner technologies in vessels even if economic and environmental arguments are favourable (Corbett and Fischbeck, 2002; Lyridis et al., 2005; Eide et al., 2009; Rivas-Hermann et al., 2015). Studies have shown that demonstration projects can facilitate energy efficient shipping practices (Krozer et al., 2003). Within the maritime sector, greenhouse gas reduction efforts have been focused on large vessels in terms of reducing fuel consumption by improved operation (Buhaug et al., 2009; Lindstad et al., 2011), and there has been less focus on small vessels. In this article, focus is on the collaborative innovation process taking place when retrofitting small vessels with cleaner technologies.

In vessel retrofit projects, technical competences from one supplier firm complement the competences of others with the aim to deliver a given product (Lyridis et al., 2005). Similarly, previous research highlights the collaborative character in the development of cleaner technologies for small vessels (Mosgaard et al., 2014a). A closer look into open innovation processes could provide insight and lead to an understanding of retrofitting projects of small vessels with cleaner technologies (Chesbrough, 2003). Inter-organisational collaboration can lead to challenges such as cognitive barriers, different norms or incentives, information and managerial gaps among partners, etc. (Klerkx and Leeuwis, 2009). Partly to address some of these challenges, innovation intermediaries are suggested as nodes in inter-organisational networks which can "perform a variety of tasks in the innovation process" (Howells, 2006). This variety of tasks implies diverse broad functions as for example: diffusion and technology transfer (Roxas et al., 2011), innovation management (Hargadon, 2002), "architects", co-creators, managers, and enablers of collaborative processes with a high degree of uncertainty on the outcomes (Agogué et al., 2013).

Despite the comprehensive literature on the role of intermediaries in innovation, the functions of intermediaries are not well known in collaborative innovation processes related to the development of demonstration projects of green technologies. The following research question is addressed in this connection:

> *How do innovation intermediaries support collaborative innovation processes taking place in green maritime technology demonstration projects?*

A case study design is applied with an innovation process perspective (Van de Ven et al., 1999) to understand the functions that intermediaries play in collaborative demonstration projects. The context of the case study is the Danish maritime sector, in which incumbent members from the value chain of the shipping industry have joined various nationwide partnerships and networks for developing green technology. In the maritime industry, green technology comprises both: a) end-of-pipe modifications at the end of the production process to reduce the release of emissions into the environment (i.e., ballast water treatment systems and exhaust gas

cleaning systems), and b) Cleaner technology to reduce emissions and energy use at the source. Examples are efficient propulsion equipment (i.e., engines, propellers, etc.), but also technology on board (i.e., lighting) in order to improve the ship's energy use and reduce costs (DNV, 2012; Jafarzadeh and Utne, 2014).

The initiatives to develop green technology were first inspired by changes in the international environmental legislation, which pushed the shipping industry to innovate in terms of how to reduce the emissions of air pollutants (SO_X and NO_X) but also how to design eco-efficient vessels and equipment to reduce operational costs. In the municipality of Frederikshavn in Northern Denmark, medium-sized enterprises (SMEs) and large firms supply products or services to the local yards or to shipping companies. These firms have found a market niche in the design and development of eco-friendly small island ferries (Mosgaard et al., 2014a; Mosgaard et al., 2014b), but also have an increasing interest in retrofitting larger ferries or any other type of vessels with green technology.

The case study is about the green retrofit of the ferry linking the small Danish island of Læsø with the town of Frederikshavn. The analysis covered the whole project period (2010-2014). As explained with greater detail in Section 3, an innovation process perspective follows the analysis of key events that shaped the project. With a basis in the conceptual framework presented in Section 2, the authors analyse the functions played by the two innovation intermediaries Frederikshavn Business Council and the Maritime Centre for Operations and Development (MARCOD) during these key events.

The structure of the article is as follows. The conceptual framework is presented in section 2 and elaborates on the role of intermediaries with a focus on the initiation and development phases of the innovation process. In Section 3, the authors present the research methods. The findings and discussion are presented in section 4, while section 5 consists of the conclusion and suggestions for further research.

2 Conceptual framework

The conceptual framework is based on the literature on functions of innovation intermediaries with special emphasis on the innovation process. The purpose of focusing on the process is to achieve a better understanding of how collaborative innovation networks are established and how innovation pathways are created through the way in which intermediaries work during the innovation journey (Van de Ven et al., 1999).

Innovation processes are defined in this article as the set of events which take place to create and modify new products, processes, or services. These events occur through a journey composed of three general periods: invention (initiation), development, and implementation (Van de Ven et al., 1999). Current models of innovation processes acknowledge the iterative and retrofit loops between these three general cycles (Rothwell, 1994). In the period of initiation, several solutions to a given problem may be proposed; then a filtering of these solutions takes place with the intention to have a possible product. External "shocks" or factors can motivate the selection of one of the possible solutions until the firm managers allocate resources for the next period (Van de Ven et al., 1999). The period of development implies improving the ideas from the previous cycle of invention. Management provides resources for this improvement, and in this period, several convergent or parallel activities and products are generated –so-called innovation pathways (Garud et al., 2013). The period of implementation

implies introducing the innovation into the market, through several activities as, i.e., transferral to potential customers and diffusion to a large number of users (Van de Ven et al., 1999).

Demonstration projects are key learning elements in a subsequent full-scale implementation or commercialization of the product (Frishammar et al., 2015). Following this scope and from an innovation management perspective, a collaborative demonstration project covers the cycles of initiation and development, but not the cycle of implementation, when the product is meant to be commercialized and diffused to a wide market of users (Van de Ven et al., 1999).

Whereas the firm is the usual locus of innovation processes (Pavitt, 2006), from an open-innovation perspective, innovation processes can spur out of the organisational boundary in multi-party networks or communities, as the firm can benefit from external research and development (R&D) by intellectual property (IP) and knowledge exchange (Chesbrough, 2003; Garud et al., 2013). Innovation intermediaries function as nodes that can perform different functions to facilitate the exchange of knowledge, among other activities in networks (Hansen and Klewitz, 2012; Klewitz and Hansen, 2014).

The knowledge-based perspective on intermediaries' role in the innovation processes has been enriched by the literature on intermediaries, which focuses on the process roles and "hidden work" of different types of intermediaries. This research stream focuses on the nature of the work of intermediaries in relation to local actors (Moss, 2009; Hargreaves et al., 2011), activities, projects (Hargreaves et al., 2013), and bridging and connecting the process in question to global and national activities and trends (Moss, 2009):

"whether facilitating dialogue, providing guidance, bridging gaps, advocating reform, or pioneering novel forms of interaction, their areas of action are defined by their in-betweenness" (Moss, 2009)

The intermediaries' ways of working and interacting play an important role in connecting and bridging actors in the innovation process; not only as a window of opportunities (Moss, 2009), but also by posing abilities to work across "often impermeable boundaries between different actor groups, areas of action or geographical scales" (Moss, 2009). In sections 2.1 and 2.2, we further elaborate on the functions of intermediaries during the initiation and development periods of collaborative innovation processes.

2.1 Intermediation in the initiation period of innovation

The initiation cycle is preceded by the "gestation" of the innovation ideas, which can span over several years (Van de Ven et al., 1999). Characteristic activities during the initiation period include idea generation and assessment, concept development, and market analysis (Herstatt and Verworn, 2001). This process is usually chaotic and is filled with trial and errors (Kim and Wilemon, 2002). One reason for this chaotic beginning is the recombination which is the main mechanism behind the initiation period. Recombination implies drawing ideas from different sources and combining these ideas in new ways; i.e., other organisational units, different organisations, and different sectors, which can eventually lead to a creative solution to the problem (Hargadon, 2002).

In collaborative innovation initiatives, intermediaries can perform different functions to support the network during the initiation period. In case no inter-firm collaboration is in place, a first

group of intermediary functions relate to how to initiate collaboration and joint projects between firms (Lefebvre, 2013):

Broad networking: The intermediary organizes several activities with the purpose that organisations get to know each other, discuss complementary aspects, and eventually strengthen their relations overtime to initiate joint R&D projects. Examples of activities are one-day workshops or study tours.

Setting up permanent workgroups: These groups are set with a reference to the network's main themes and focus areas. The intermediary invites firms working under the themes. Challenges appear for firms with limited R&D resources or no possibilities of allocating resources to the project.

Setting up temporary ad hoc groups based on (emerging) sub-themes: Workgroups are initiated around themes suggested by the network members, rather than predefined by the intermediary organisation. The intermediary has the function to decide which firms to invite to the workgroup meetings, with the selection criterion that the firm will provide a meaningful contribution to the workgroup.

If the collaboration is in place, the intermediary can provide other functions with the goal of diffusing knowledge among partners of the network (Agogué et al., 2013). The following are brokering functions (Howells, 2006):

Foresight, forecasting and technology road mapping: The intermediary support is to define the needs and requirements that the firm should have to keep up to date with the newest technological developments (Klewitz et al., 2012). Market forecasting has been suggested as one example (Lichtenthaler, 2013). With a case study of the fashion industry, Tran et al. (2011) suggest that foresight and forecasting cover the analysis of trends and competition and the organisation of site visits to identify new developments.

Scanning and information processing: The intermediary facilitates knowledge circulation into the firms within the innovation system. This is the case of joint research centres that build absorptive organisational capacity in SMEs to participate in open innovation processes along with other organisations in the innovation system. Examples of the activities that they perform are knowledge intelligence services (gatekeeping, technology watch, road mapping), organizing study days, and keeping technical repositories or technical libraries (Spithoven et al., 2011).

2.2 Intermediation in the development phase of innovation

A milestone of the development period is the allocation of a budget from the partner organisation(s) to the project activities. Once the budget is in place and organisations start to develop the innovation, several possible prototypes can be developed in divergent innovation pathways. Prototypes become important in connecting people and contextualizing the product in the social setting (Garud et al., 2013). The creation of different prototypes as a result of different innovation pathways may result in setbacks or in more successful products, which will ultimately be improved to launch to the market (Van de Ven et al., 1999). Therefore, Garud et al. (2013) have defined the development phase as one in which many actors are involved and not all of them face a win-win situation.

Innovation intermediaries can support the partners during the development period by providing the following functions:

Testing, validation and training: Some intermediaries can provide infrastructure support in the form of test chambers, laboratories, prototyping, and pilot testing facilities. Other functions of intermediaries are validation of the technology being developed and joint training in the use of these new technologies (Howells, 2006).

Knowledge processing, generation and combination: From this perspective, intermediaries are organisations or individuals with a broad palette of skills and knowledge from different industries. In this way, the intermediaries are able to "recombine" knowledge from different industries (Hargadon, 2002; Gassmann et al., 2011). This process of recombination has been extensively analysed by Hargadon (2002) through the knowledge brokering model of innovation. This model implies that intermediaries (organisations or individuals) gain access to the resources from multiple institutional, organisational domains ("small worlds"), which are unknown to other domains. Later they share these resources and knowledge in new contexts (industries, sectors). Gassmann et al. (2011) present examples of service organisations in three categories:

i) Innovation multiplier: Service organisations that multiply their technological specialization in different domains;
ii) Innovation leveragers: Contribute to cross-industry projects by applying methodological and technical knowledge from previous projects;
iii) Innovation broadeners: Often lack in-house capabilities but rely on their methodological skills and networking to find appropriate ideas for inter-industry recombination projects.

Accreditation and standards: The types of activities that innovation intermediary organisations carry out are: setting specifications or providing advice on standards or formal verification of standards (Howells, 2006).

The conceptual framework position collaborative demonstration projects in the periods of initiation and development according to Van de Ven et al. (1999). The conceptual framework also summarizes the main functions of intermediaries in both periods.

3 Research design and methods

This section presents our inquiry strategy as a qualitative case study. In section 3.1, we argue about the suitability of a case study strategy for our research goals, including our position on scientific validity. Section 3.2 discusses the strategy for data collection and the reliability of the qualitative methods.

3.1 Case study

We opted for a case study inquiry strategy because we seek to explain how innovation intermediaries support collaborative innovation processes taking place in green maritime technology demonstration projects. Case studies are appropriate for explanatory research questions of the type "how". Case studies focus on contemporary social phenomena events over which the researcher has no control (Yin, 2014).

We defined the boundaries of the single case study as the innovation processes related to the project "Green Læsø Ferry" in the period of 2010-2014. The authors selected the case following an information-oriented selection: *"cases are selected on the basis of expectations about the information content"*(Flyvbjerg, 2011). The Maritime Centre for Operations and Development (MARCOD), which is located in Frederikshavn in North Denmark, is in charge of the "Green Læsø Ferry" retrofit project. One of the authors has been a research fellow at MARCOD and has been closely interacting with the project facilitators since the end of 2011. In Denmark, several initiatives are trying to build collaborative innovation projects in the shipping industry (Rivas-Hermann et al., forthcoming). In these initiatives, maritime suppliers and shipowners can join together to develop new prototypes (Mosgaard et al., 2014b). However, the case study presented is not about radical innovation in the construction of new ships, but a case study of the intended innovation of green retrofit of small island ferries through demonstration projects. The classification of innovations as radical or incremental relates to the potential environmental improvements and the level of change involved. Radical innovations involve the application of new knowledge, new technology, and a new organizational framework in a way that interrupts the existing practices in the sector (Verganti, 2008). Incremental innovations also reduce the environmental impact but based on existing knowledge, technology, behaviour, and organizational framework (Verganti, 2008). An example of radical innovation would be the construction of a new ship using composite materials as presented in more detail in Mosgaard et al. (2014a). In contrast, the "green" retrofit of older vessels is about incremental improvements in the environmental performance of the vessel by, e.g., the reduction of energy consumption with a LED lighting system in the car deck.

The case study was also selected because the innovation intermediaries played a key role in the initiation of the collaborative innovation network. As long as the actors accomplished project milestones, the role of the intermediaries changed accordingly. This time perspective allowed us as researchers to understand the role of intermediaries along the innovation process (i.e., by being "observers" from the early phases of the project back in 2011). In this way, we made an adaptation of longitudinal analysis of the innovation processes; research that seeks to address the issue of organisational change, development, growth and evolution over a period of time (Van de Ven and Huber, 1995; Van de Ven and Poole, 1995).

When selecting the case study, we took into consideration to which extent the results from the case study could be generalized to and across other contexts. External validity or generalization is one of the key criticisms towards case studies as scientific methods (Calder et al., 1982; Flyvbjerg, 2011). We propose "empirical generalization", which does not wish to generate a universal theory applied in any context. Instead, the theoretical contributions of the case study are context-dependent and can be transferred to a small population, preferably similar to the one of the case study (Tsang, 2013). In our case study, the functions of intermediaries during the initiation and development of green retrofit projects could be generalized according to empirical generalization.

3.2 Empirical data and analysis

The collection of empirical materials was an adaptation of the research approach known as systemic recombining that is characterized by a "continuous movement between the empirical world and the model world" and is abductive rather than inductive or deductive (Dubois and Gadde, 2002). To follow this abductive method, the authors first achieved an initial understanding of the case study through observation over a period of time (2011-2014), as one of the authors participated in weekly meetings in MARCOD, where the project Læsø Green

Ferry was discussed. This understanding guided a literature review including the subjects of SMEs and eco-innovation barriers and drivers. The review had the purpose to guide an interview with a consultant from MARCOD, who was facilitating the demonstration project in 2014. After this exploratory interview, the authors modified the literature review by focusing on the innovation process and the role of intermediaries.

The updated literature review provided new propositions that were turned into a semi-structured interview guide covering five topics: the project definition and scope, internal processes in the organisation, external actors, collaboration process, and the function(s) of the intermediaries in the project. This guide was used for nine additional interviews with a mean length of 90 minutes. As described in Appendix A, the interviewees were selected using a combination of informed and snowball sampling strategies (Rubin and Rubin, 2012). The informed sample, gathered through the project minutes included all the facilitators from the intermediary organisations, the technical officer and the director of Læsø Ferry. Subsequently, these initial interviewees suggested key informants for further interviews (snowball sampling). In this way, we interviewed staff from firms that participated in the initial phases of the project and staff from firms that developed or installed products on board the ferry.

In addition to interviews and observations, the authors carried out a document review with the purpose to verify the data collected through the other two methods (triangulation) (Miles et al., 2013). The documents were provided by the intermediary organisations MARCOD and Frederikshavn Business Council. The documents included email communications, meeting minutes, a catalogue of products and services, an Excel list of firms with interest in the project, power point presentations, technical and financial quotes, and formal contracts.

To analyse the empirical data, the authors used a combination of two methods. The purpose of both is to identify the key events that build the innovation process, the role of intermediaries and other actors. The first was to synthetize the case study through matrices and event-action diagrams (Miles et al., 2013). The second method was to prepare a coding guide (codebook) to analyse the interview transcripts (Saldaña, 2009). The literature review provided a set of codes that were turned into interview questions. The question codes were complemented with theoretical codes from the literature on innovation processes and innovation intermediaries. Examples of these codes were: “com_drivers” (drivers for the firm to engage in the project) and “ext_agreements” (type of agreements between the partners in the project). With this initial set of codes, the authors analysed the interview transcripts. This analysis brought new emerging codes as well, following the method of grouping codes into categories and themes (Saldaña, 2009).

4 Analysis and discussion

For analytical reasons, we present the green retrofit of the ferry in two periods: initiation and development. The logic behind this separation into periods is that different types of processes take place with different stakeholders, intermediation roles, resources and outputs. As Figure 1 sketches, the project has extended over five years, but the periods did not follow a chronological order, as they were rather continuous and interrelated. The initiation period took place between 2010 and part of 2012. The development period started in the first months of 2012 and extended until the last months of 2014.

[Figure 1 here]

In this case study, we aim to explain the functions of intermediaries in the initiation and the development of the demonstration project. The section ends with a review of the conceptual framework in relation to the findings, and a discussion about which kinds of challenges the intermediary organizations face in the innovation journey.

4.1 Functions of intermediaries during the initiation of the collaborative demonstration project

Frederikshavn Business Council was involved in EU-funded Interreg maritime projects with Scandinavian partners before the formal start of the demonstration project "Green Ferry". These projects had the purpose to prepare the Nordic maritime industry for new regulations in the use of low sulphur maritime fuels. During this period, the first intermediary played a role of foresight by reflecting upon the local changes in the market that may introduce the demand of new products and services for the shipping industry, as vessels shall be retrofitted to adapt to the new low sulphur fuel in the Baltic and North Seas. The period can be considered a "gestation" period as nurturing of ideas and inspiration was required to initiate an innovation process (Van de Ven et al., 1999).

Inspired by this potential market, the Business Council in collaboration with the Municipality of Frederikshavn hosted the Maritime Business Conference at the end of 2009. During this conference, the local participants initially discussed the idea to develop a 1:1 scale demonstration project of a green ship in Frederikshavn to "demonstrate" what the local companies would be able to supply and install. At the outcome of the conference, the participating companies were interested in finding a ship for a demonstration project, and the possibility was to find a shipowner willing to participate in the consortium by providing a ship for retrofitting. The Business Council first approached the Ministry of Defence without success. The Municipality of Frederikshavn contacted the Business Council and suggested that a feasible retrofit project was the ferry connecting Frederikshavn with the island of Læsø. The ferry company agreed to participate with the ship Margrethe (built in 1997), which had a dry-dock routine maintenance in 2012, and the company's expectation to the project was to obtain a detailed offer of technologies for retrofitting the ship. In addition, the project could bring some external subventions for optimizing the energy use on board. At this point of the project, the intermediary had the function of "broad networking" by first organizing a conference with an open character, then ensuring that any input from the participants was welcomed. The overall idea with "broad networking" was to generate some ideas for joint R&D activities among local companies.

The Business Council then invited some companies to participate in an ad hoc workgroup of marine suppliers interested in participating in the green retrofit of the Margrethe Læsø ferry. The creation of the ad hoc group generated a great expectation among local suppliers, as illustrated in Table 1 by the number of local firms participating in the initial activities. Given the open characteristics of the setting where the idea was proposed, environmental improvement had a broad meaning and each participating firm tried to include their services and products in the initial concept of the green ship. At this time, some of the companies were only motivated to sell their products, just as in any conventional project. But some were also motivated to have a physical showcase and a test place for marketing purposes (interview 2). The mechanism of intermediation differed here from two other strategies proposed by Lefebvre (2013) in the collective exploration mechanism as "broad networking" or "setting up permanent working groups".

[Insert Table 1 here]

The Business Council expected that the sub-groups of companies within the larger ad hoc network would deliver technical proposals and budgets; i.e., the companies delivering solutions on lighting and energy supply would be one sub-group. The coordination of the ad hoc group brought some challenges to the intermediaries, in particular, when partners had overlapping offers in the kinds of products and services that they could deliver (Interview 2). The issue with overlaps of offerings did not disappear in these sub-groups. When asked why they never sent the quotes to the facilitators, one of the firms answered that in their perspective they were "competing" in a tender rather than developing a joint initiative with the other participating firms. Here the intermediary, the Business Council, had the function of "collector" once more, as it collected these different technical proposals and then left the ferry company with a last decision on what was feasible.

The Business Council supported the ferry company to decide which technical options were feasible. Both organisations narrowed down the project to three aspects: reduction of noise, improvement of propulsion, and improvement of the lighting system. None of these three options materialized in concrete projects. The noise reduction and propulsion improvement did not present an acceptable payback time at first, but the company has plans to implement it the next time that the propeller blades have to be replaced due to sand erosion from sailing in shallow waters. The lighting system exchange is planned to be implemented along the road by use of the ferry company's own electricians, avoiding expensive external companies for this job. In general, green projects in small island ferries have experienced a drawback in terms of a government policy to support island economies by relieving island ferry companies of fuel taxes. This increases the payback time for energy saving projects by five to ten years in actual green retrofit projects. In the context with no fuel tax, some ideas of green retrofit needed further external funding to be implemented and work as demonstration installations (Interview 1).

As this set of events shows, even with the support of the intermediary to scan information, the power of decision of the ferry company was strong in the collaborative network. It was the ferry company that determined which kinds of innovation pathways to follow. As one intermediary consultant put it: "I had difficulties to steer the project in a given direction. I could not force the partners to make certain decisions. We had to wait for the decisions from the ferry company and then act accordingly" (Interview 10). This quote calls for a reflexion of why intermediaries should be the ones handling these tensions in demonstration projects.

4.2 Functions of intermediaries during the development of the collaborative demonstration project

After the selection of partners and technologies, as mentioned in section 4.1, the intermediary MARCOD took a lead role in the development of a Ship Energy Management System (SEMS). In parallel, the technical officer from the ferry company took the initiative in retrofitting the Heating Ventilation and Air Conditioning System (HVAC). This set of decisions marks the start of the development phase, not only because a budget was raised for the SEMS, but also because as part of the development of SEMS other associated products were developed, i.e., the HVAC. This situation also seems to correspond to Van der Ven's (1999) assumption that different divergent and then convergent pathways of product development can take place within the same project.

The project SEMS was the initiative of a new consultant working for MARCOD, an electrical

engineer with previous experience in a major shipping company that followed similar retrofits in their fleet. This shipping company needed a baseline to benchmark the accomplishments of the retrofits concerning the energy efficiency of the vessels. The consultant translated the same approach to the retrofit project and proposed it as a project idea. In the background of the first "pathway", the key function of knowledge recombination is carried out by a new consultant from MARCOD. Knowledge recombination implies that individuals connect ideas from different fields, institutions, and organisations to generate innovations (Hargadon, 2002).

In order to further develop this project idea, the consultant from MARCOD contacted a Technical Institute, which provides consultancy, training and safety certification in a broad field of domains, including monitoring devices. Both organisations – in collaboration with the Læsø Ferry company – prepared an initial project idea proposal. The proposal was based on a similar project from the Danish Technological Institute named "energy flexhouses", a system for domiciliary use. This original system had a user interface to demonstrate energy consumption.

Later, a student from the Maritime and Polytechnic College from Frederikshavn (MARTEC) was writing her engineer thesis in collaboration with a large manufacturer of electronic equipment located in the city of Skive. The project involved technical options to measure the energy use on board a ship. The student attended a MARCOD seminar and was then invited to present her project to the facilitator of the Green Ferry project. The consultant from MARCOD knew about the electronic manufacturer and was aware of their work; he considered that their software could complement the technical proposal that MARCOD was preparing with the Danish Technological Institute. Since this key event, MARCOD, the Danish Technological Institute and the electronic manufacturer decided to collaborate in a new proposal in which all three were involved. After some months, the three partners and the ferry company agreed on the product concept: an interactive monitor system that informs the users about the energy consumption on board the ship, but in any case it should be a control system. The given name was Ship Energy Management System (SEMS).

MARCOD had a more active role in the process to consolidate the connectivity between the members of the ad hoc network for developing SEMS. The increasing connectivity was connected to three main activities: a) Defining partners' roles and inviting external actors, b) Improving communication among partners involved in the SEMS project, and c) Fundraising.

First, defining the roles of each partner and inviting an external partner to support the incipient network. During the initial development of SEMS, the partners had a commitment about each organization's role. The electronics company became a member of Danish Maritime (marine equipment branch organization), as a condition to have Danish Maritime as a fourth partner in the application for innovation funds. The partners agreed that Danish Maritime should be the coordinator of the activities and promote the project at a national or international level. The Danish Technological Institute should provide technical support on the software/ user interface. Finally, the Læsø ferry company collaborated with the electronics company in the installation of hardware.

A second activity by MARCOD was to improve the communication among the members of the network of firms working on SEMS. In the time between applying for funds and receiving the subvention, the roles of the partners changed. The electronics firm considered that all the responsibilities had fallen into their hands: applying for the project, coordinating the activities, delivering the software and doing the installations: "*We thought that we were just going to*

supply the know-how but we are now controlling the whole project" (Interview 6). The consequence was that the electronics firm started with the project but lacked some inputs from the other partners, in for example, how to set-up SEMS in a way that could be compatible with other technology that could later be installed on board (i.e. LED lighting):

> *"We missed some inputs from some people, some others that were also involved in the whole retrofit project. We thought it was part of the cooperation. We thought that the whole "green ship" project was big, but suddenly it was a small project. We haven't been in contact with any other company besides MARCOD and the Danish Technological Institute. It will be very nice if different companies supplying systems for the ship could work together and more closely discuss how to configure the different equipment in a way they are compatible from the start. I'm sure there would be minor problems of this kind. But if it is possible to work with those suppliers from the start these kinds of problems could be avoided" (interview 6).*

The third function was to raise funds to sustain the network's project and support the ad hoc group in collaborative product development. This function implied writing a project application with detailed accounts of technical, economic and marketing aspects. The intermediary also provided support by contacting the partners to fill in the application forms and meeting the potential funders. The Danish Maritime Fund provided a grant to develop SEMS. The subvention covered half of the hourly expenses for the electronics company. The provision of this grant was a milestone in terms of new functions for the intermediary organisation enhancing network connectivity. The creation of a well-functioning ad hoc group means new tasks in the development phase. Existing literature fails to explain these functions.

The intermediary must be able to orchestrate the different activities of the ad hoc group in a way that complies with the subscribed commitments. In the case of the SEMS ad hoc group, MARCOD began to coordinate the different activities carried out by partners of the sub-projects through one-to-one meetings and visits. After some months, MARCOD decided to interrupt this mechanism as it brought some challenges, including in terms of how to follow up on the compliance of the initial commitments of all actors involved in the sub-project or how to speed up decisions in the project in general.

The second pathway (HVAC development) shows that bilateral relations between industries can generate innovation through knowledge recombination without the support of the intermediary, but later the intermediary plays the role of broker. During the last months of 2012, the ferry company's chief technical officer assessed that the ventilation was not working properly. Some pumps were running out of time and needed an overhaul to save energy. He had good referrals of a large company specialized in industrial and maritime refrigeration based in the city of Aarhus, which he contacted. After an on board inspection, an engineer from this company suggested to reuse the excess heat and considered that this could be a good case for his own company for further product development.

The engineer presented the project idea to the top management. They were positive about the involvement in the HVAC project in the Margrethe Læsø ferry, but suggested that the engineer should use interest hours to work on it. Interest hours are distributed internally between the employees, to work in activities that are not necessarily for short-term profit but can bring benefits in the long term. One type of benefit was the knowledge generated about the product that can be applied to other ships with similar conditions. Another benefit was the possibility to optimize the HVAC system once installed; the company already had experience with live-monitoring of other refrigeration equipment in, e.g., fishing vessels. The constant internet-based monitoring allows the firm to develop big-data analysis of the performance of the equipment over time.

The collaboration between the Læsø ferry and the industrial refrigeration firm implied negotiations with authorities to approve the use of ammonia in the HVAC system. The ferry technical officer was in charge of contacting external actors in order to facilitate the negotiations and improve the acceptance.

In line with these safety approvals, the HVAC system partners approached MARCOD for support. The approval of an independent third party was part of the process to get the operation permits from the authorities and the classification society. MARCOD contacted a technical approver organisation, FORCE, which showed interest in the project.

4.3 The role of intermediaries in collaborative environmental projects: key lessons from the case study

Our analyses show that intermediaries had a broad range of functions during the initiation and development of the demonstration project. These functions became even more complex because two organisations acted as intermediaries during the project period (2010-2014): Frederikshavn Business Council and the Maritime Centre for Operations and Development –MARCOD (Table 2).

[Insert Table 2 here]

Intermediaries had a broad range of functions during the initiation and development of the demonstration project (Figure 2). In contrast, other case studies on innovation intermediaries have constantly focused on one function of intermediaries, i.e., forecasting (Lichtenthaler, 2013; Chunhavuthiyanon and Intarakumnerd, 2014), scanning and information processing (Malik, 2012), brokering (Tan et al., 2010; Feller et al., 2012), and networking (Colombo et al., 2014) without describing other possible combinations. In this section, we first analyse how intermediation roles differed along the innovation journey. Then, we explain how these roles were connected to organizational characteristics of the intermediaries, e.g., business strategy and competences at both organization and consultant level.

[Insert Figure 2 here]

4.3.1 Intermediaries' role during the initiation period

During the initiation period, the intermediary role was played by Frederikshavn Business Council. Some of the functions of this role were to find a ship for retrofit, invite companies to join the ad hoc group, and collect technical offers from the partners. The intermediary could rely on its competences as a business council with a good knowledge of the local industry and close cooperation with public institutions. Besides, the intermediary also relied on broader competences to support and organise networks of firms. The intermediary *organized* a conference to stimulate the process of idea generation and networking, which ended up with a common idea of a "green" ferry demonstration project as a show case for the local industry's capabilities in retrofitting.

This broad competence was important in this period, but the lack of focus on the maritime sector brought challenges in relation to the intermediary's engagement in the activities and ability to support the process in the critical phases of selecting suppliers, retrofitting technologies and

finding a ship as a demonstration object. As result of these challenges met by the intermediary, the initial list of retrofit technologies did not succeed in translating into real retrofit packages during the development process. The Business Council hired temporarily an external assessor from a maritime service firm to overcome some of these deficiencies, but also to give ideas and carry out the functions of scanning and information processing. The intermediary carried out a *foresight analysis* to show the market opportunities and create interest for networking.

In spite of the companies' interest in a demonstration project, it was not a smooth process to initiate the green retrofit of the ferry Margrethe Læsø. The companies were involved in the usual business activities and had difficulties engaging new resources to initiate new activities for the future. Thus, the intermediary handled the tensions between competing interests in the inclusion of different products in the retrofit package, and assisted in finding a ship that could function as a learning lab.

The intermediary played a central role in selecting the suppliers and finding the ship for the demonstration project. The choice of the ship became crucial for the whole set-up, because the selection criteria shifted from identifying the market opportunities to questioning the opportunities of the chosen ship and defining an acceptable payback time for the owners of the ship.

The initiating period was not a simple process of idea generation and getting the interested companies together. Instead, it was a complex process in which the intermediary played different roles in creating and facilitating market opportunities, motivating and stimulating the business interest, managing different interests, and setting up the partnership.

4.3.2 Intermediaries' role during the development period

During the development phase, the new intermediary (MARCOD) took over as project coordinator in order to facilitate and initiate the development process in close collaboration with the ferry company, which had become the key owner of the demonstration project. This new intermediary had as a part of its organisational mission to become a maritime cluster management organisation in the long term, and the Læsø ferry project was an important first step to gain concrete experience in coordinating a collaborative innovation project. This organisational aspect also influenced the type of intermediation proposed in the development of the demonstration project.

The key challenges during the development period were to transform ideas and technology into solutions and to facilitate the collaboration which could make this transformation possible (Hargadon, 2002). The different events during this period entailed different challenges and roles for the intermediary. The intermediary played a central role in the SEMS project by *translating* the idea of energy efficiency to vessels and *recombining knowledge and partners*. The intermediary played another role by identifying the development challenges and setting up a network of actors and activities, which could develop a solution. The intermediary used its maritime knowledge and competence to *identify the key actors* and had the capabilities to *facilitate and coordinate* the project externally. The last function was important in relation to getting funding for the project. The internal dynamics and interaction among the involved partners was determined by the different partners' capabilities and interests.

The HVAC project was carried out by the ferry company and an established maritime equipment supplier. Both perceived the opportunities in transferring the existing knowledge of land-based heat exchangers to ships. In this self-initiated project, the intermediaries functioned as brokers in relation to safety and certification approvals.

The development period was not a simple process of creating technical solutions and getting the right partners together. It was a complex process in which the role of the intermediary adjusted according to the challenges that emerged along the development period. In the SEMS development, the intermediary played an active role by facilitating both the process to find technical solutions and the process of network building. In the HVAC development, the role of the intermediary was secondary because the ferry company and its supplier networked and developed a solution independently. In both cases, the stakeholders faced a complex process by balancing their own interests vis-à-vis the retrofit packages, the intermediary facilitating the collaboration among actors, and the way that the ferry company chose to prioritise the different technical proposals. The intermediary played a supportive role and facilitated the different activities in the project whenever it was possible, but could not influence the decision of implementing a given retrofit technology.

5 Conclusions

The guiding research question was: *When and how do intermediaries support collaborative innovation processes taking place in environmental demonstration projects?*

Two innovation intermediaries (Frederikshavn Business Council and MARCOD) played different functions in the environmental demonstration project Læsø green ferry retrofit presented in this case study. The first intermediary supported the creation of an ad hoc group that became the basis for a demonstration project. The organisation of this group was possible because the intermediary had other functions (forecasting and broad networking before organising the ad hoc group; brokering along with the formation of the group). The second intermediary supported the ad hoc network to increase its connectivity and initiated the development of two products: a ship energy monitoring system and a closed-loop HVAC.

In addition, the results contributed to the understanding of how intermediaries increase the network connectivity during the development phase of innovations. Intermediaries can play simultaneous functions in innovation processes. Some of these functions become key steps to initiate and keep collaboration in a network of companies; as for example, during the development phase of SEMS, the intermediary had the functions of increasing connectivity in the network, while at the same time provide brokering. While individual functions discussed in the case are consistent with literature, the interaction between these different functions provides a closer understanding of innovation processes in collaborative demonstration projects. In the development phase, the knowledge recombination function has a close interaction with the functions of brokering as ideas from one organization (not necessarily involved in the project) can be beneficial for the project, provided that the persons with the ideas can be connected with others partners in the project (i.e., in the development of SEMS, an external student provided good ideas to the electronics firm in the consortium which later turned into the basic concept of SEMS).

The intermediaries' various functions also influenced the innovation pathways. This was evident from the beginning of the Læsø Green Ferry Retrofit, when the intermediary played a key role by

finding a ship to retrofit, inviting companies to join the ad hoc group, collecting technical offers from the partners, etc. The ferry company had the last and final decision on which type of product would be part of the retrofit and discarded technical sound offers (i.e., LED lighting on the car deck). The innovation pathways were in some ways the result of fulfilling the ship-owner's financial and technical needs rather than a consensual plan of all the companies that showed an initial interest in the project. The financial and the organizational context of the ferry company also had an influence on these decisions. The solution may well be feasible for other ship types. A conclusion from this finding is that, in collaborative demonstration, the primary goals can shift due to the innovation pathways undertaken as new ideas emerge over time and new partners join the network, which is a similar situation for all innovation processes. An additional intermediary function should be that of defining each partner's role and secure a clear goal of the work performed by the network. As seen from this case, the intermediary must have experience in negotiating these evolving partners' roles.

The theoretical focus on intermediaries combined with innovation theory has created the foundation for a process-oriented study of the roles of intermediation in an innovation process. We have shown that the role of the intermediaries goes beyond the well described functions related to, e.g., forecasting, scanning and information processing, brokering and networking. Especially the function as a technological knowledge partner that can help in the process of selecting the right actors to participate in the processes has been of importance. Due to the technological knowledge of the intermediaries, they were also able to participate actively in the process of getting security verification and funding for the technologies. This means that the intermediary is not a partner that brings the other actors together but an actor that participates in the interactions both internally in the network and in the institutional setting related to the technologies developed.

One limitation of the research approach was the overall attention to the intermediaries' function in the collaborative innovation network. This strategy hindered the analysis of the functions of other actors in the actor network. The authors were conscious about this choice, as previous research on eco-innovation in small island ferries has focused on the actor network configuration, but disregarded the analysis of innovation intermediaries, i.e., Mosgaard et al. (2014a, 2014b). The case study presented a series of drivers and barriers that intermediaries face when facilitating green retrofit projects in small vessels. However, the identification of drivers and barriers was not the main focus of our research. Further research could supplement our findings by analysing drivers and barriers from the perspective of the other actors (i.e. suppliers) who are involved in the innovation processes.

A second limitation was the focus on the initiation and development of demonstration projects. The intermediaries' contribution was not analysed in terms of the diffusion/ commercialization of these innovations. Further research could analyse the role of intermediaries in the diffusion of innovations resulting from collaborative demonstration projects. Similarly, the case study also indicated the importance of the context; therefore, further contributions from other sectors and countries could provide a better indication of which other roles intermediaries play and how these roles influence the innovation pathways.

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References

Agogué, M., Yström, A. and Le Masson, P. (2013) 'Rethinking the role of intermediaries as an architect of collective exploration and creation of knowledge in open innovation', *International Journal of Innovation Management*, Vol. 17 No.2, pp. 1350007_1–1350007_24.

Buhaug, Ø., Corbett, J. J., Endresen, Ø., Eyring, V., Faber, J., Hanayama, S., Lee, D. S., Lee, D., Lindstad, H., Markowska, A. Z., Mjelde, A., Nelissen, D., Nilsen, J., Pålsson, C., Winebrake, J. J., Wu, W. –Q. and Yoshida, K. (2009) *Second IMO GHG Study*. London: International Maritime Organization.

Calder, B. J., Phillips, L. W. and Tybout, A. M. (1982) 'The concept of external validity', *Journal of Consumer Research*, Vol. 9 , pp. 240–244.

Chesbrough, H. (2003) 'The era of open innovation', *Sloan Management Review*, Vol. Summer , pp. 35–41.

Chunhavuthiyanon, M. and Intarakumnerd, P. (2014) 'The role of intermediaries in sectoral innovation system: The case of Thailand's food industry', *International Journal of Technology Management and Sustainable Development*, Vol. 13 No.1, pp. 15–36.

Colombo, G., Dell'Era, C. and Frattini, F. (2014) 'Exploring the contribution of innovation intermediaries to the new product development (NPD) process: A typology and an empirical study', *R and D Management*, Vol. 45 No.2, pp. 126–146.

Corbett, J. J. and Fischbeck, P. S. (2002) 'Commercial marine emissions and life-cycle analysis of retrofit controls in a changing science and policy environment', *Naval Engineers Journal*, Vol. 114 No.1, pp. 93–106.

DNV (2012) *Shipping 2020*. Oslo: Det Norske Veritas- Germanischer Lloyd.

Dubois, A. and Gadde, L.-E. (2002) 'Systematic combining: an abductive approach to case research', *Markets as Networks*, Vol. 55 No.7, pp. 553–560.

Eide, M. S., Endresen, Ø., Skjong, R., Longva, T. and Alvik, S. (2009) 'Cost-effectiveness assessment of CO2 reducing measures in shipping', *Maritime Policy & Management*, Vol. 36 No.4, pp. 367–384.

Feller, J., Finnegan, P., Hayes, J. and O'Reilly, P. (2012) '"Orchestrating" sustainable crowdsourcing: A characterisation of solver brokerages', *Journal of Strategic Information Systems*, Vol. 21 No.3, pp. 216–232.

Flyvbjerg, B. (2011) ‘Case study’, in Denzin, N. K. and Lincoln, Y. S. (eds) *The SAGE Handbook of Qualitative Research, 4th Ed.* Thousand Oaks, CA: Sage, pp. 301–316.

Frishammar, J., Söderholm, P., Bäckström, K., Hellsmark, H. and Ylinenpää, H. (2015) ‘The role of pilot and demonstration plants in technological development: synthesis and directions for future research’, *Technology Analysis and Strategic Management*, Vol. 27 No.1, pp. 1–18.

Garud, R., Tuertscher, P. and Van de Ven, A. H. (2013) ‘Perspectives on Innovation Processes’, *The Academy of Management Annals*. Routledge, Vol. 7 No.1, pp. 775–819.

Gassmann, O., Daiber, M. and Enkel, E. (2011) ‘The role of intermediaries in cross-industry innovation processes’, *R and D Management*, Vol. 41 No.5, pp. 457–469.

Hansen, E. G. and Klewitz, J. (2012) ‘Publicly mediated inter-organisational networks; a solution for sustainability-oriented innovation in SMEs?’, in Wagner, M. (ed.) *Entrepreneurship, innovation and sustainability*. Sheffield, UK: Greenleaf, pp. 254–278.

Hargadon, A. B. (2002) ‘Brokering knowledge: Linking learning and innovation’, *Research in Organizational Behavior*, Vol. 24 , pp. 41–85.

Hargreaves, T., A., H., Longhurst, N. and Seyfang, G. (2011) ‘Sustainability transitions from the bottom-up: Civil society, the multi-level perspective and practice theory’, *Working Paper - Centre for Social and Economic Research on the Global Environment*, No.1, pp. 1–26.

Hargreaves, T., Hielscher, S., Seyfang, G. and Smith, A. (2013) ‘Grassroots innovations in community energy: The role of intermediaries in niche development’, *Global Environmental Change*, Vol. 23 , pp. 868–880.

Herstatt, C. and Verworn, B. (2001) *The ‘fuzzy front end’ of innovation, Working Paper No. 4, Department of Technology and Innovation Management*. Hamburg: Technical University of Hamburg.

Howells, J. (2006) ‘Intermediation and the role of intermediaries in innovation’, *Research Policy*, Vol. 35 No.5, pp. 715–728.

Jafarzadeh, S. and Utne, I. B. (2014) ‘A framework to bridge the energy efficiency gap in shipping’, *Energy*, Vol. 69 , pp. 603–612.

Kim, J. and Wilemon, D. (2002) ‘Focusing the fuzzy front-end in new product development’, *R and D Management*, Vol. 32 No.4, pp. 269–279.

Klerkx, L. and Leeuwis, C. (2009) ‘Establishment and embedding of innovation brokers at different innovation system levels: Insights from the Dutch agricultural sector’, *Technological Forecasting and Social Change*, Vol. 76 No.6, pp. 849–860.

Klewitz, J. and Hansen, E. G. (2014) ‘Sustainability-oriented innovation of SMEs: a systematic review’, *Journal of cleaner production*, Vol. 65 , pp. 57–75.

Klewitz, J., Zeyen, A. and Hansen, E. G. (2012) 'Intermediaries driving eco-innovation in SMEs: A qualitative investigation', *European Journal of Innovation Management*, Vol. 15 No.4, pp. 442–467.

Krozer, J., Mass, K. and Kothuis, B. (2003) 'Demonstration of environmentally sound and cost-effective shipping', *Journal of Cleaner Production*, Vol. 11 , pp. 767–777.

Lefebvre, P. (2013) 'Organising deliberate innovation in knowledge clusters: From accidental brokering to purposeful brokering processes', *International Journal of Technology Management*, Vol. 63 No.3-4, pp. 212–243.

Lichtenthaler, U. (2013) 'The collaboration of innovation intermediaries and manufacturing firms in the markets for technology', *Journal of Product Innovation Management*, Vol. 30 No.SUPPL 1, pp. 142–158.

Lindstad, H., Asbjørnslett, B. E. and Strømman, A. H. (2011) 'Reductions in greenhouse gas emissions and cost by shipping at lower speeds', *Energy Policy*, Vol. 39 No.6, pp. 3456–3464.

Lyridis, D. V., Psaraftis, H. N., Ventikos, N., Zacharioudakis, P. and Dilzas, K. (2005) 'Cost-benefit analysis for ship automation retrofit: The case of icebreaker frej', *Marine Technology*, Vol. 42 No.2, pp. 113–124.

Malik, K. (2012) 'Use of knowledge brokering services in the innovation process', in *2012 IEEE 6th International Conference on Management of Innovation and Technology, ICMIT 2012*, pp. 273–278.

Miles, M. B., Huberman, A. M. and Saldaña, J. (2013) *Qualitative Data Analysis: A Methods Sourcebook*. Thousand Oaks, CA: Sage.

Mosgaard, M., Riisgaard, H. and Kerndrup, S. (2014a) 'Light Island Ferries in Scandinavia: A Case of Radical Eco-innovation', in Azevedo, S. G., Brandenburg, M., Carvalho, H., and Cruz-Machado, V. (eds) *Eco-innovation and the Development of Business Models*. Heildelberg: Springer (Greening of Industry Networks Studies), pp. 275–295.

Mosgaard, M., Riisgaard, H. and Kerndrup, S. (2014b) 'Making carbon-fibre composite ferries a competitive alternative: the institutional challenges', *International Journal of Innovation and Sustainable Development*, Vol. 8 No.3, pp. 290–310.

Moss, T. (2009) 'Intermediaries and the governance of sociotechnical networks in transition', *Environment and Planning A*, Vol. 41 No.6, pp. 1480–1495.

Pavitt, K. (2006) 'Innovation Processes', in Fagerberg, J. and Mowery, D. C. (eds) *The Oxford Handbook of Innovation*. Oxford: Oxford University Press, pp. 86–114.

Rivas-Hermann, R., Köhler, J. and Scheepens, A. E. (2015) 'Innovation in product and services in the shipping retrofit industry: a case study of ballast water treatment systems', *Journal of Cleaner Production*, Vol. 106 , pp. 443–454.

Rivas-Hermann, R., Smink, C. K. and Kerndrup, S. (forthcoming) 'Partnerships for environmental technology development in the shipping industry: two Danish case studies', *International Journal of Innovation and Sustainable Development*.

Rothwell, R. (1994) 'Towards the fifth generation innovation process', *International Marketing Review*, Vol. 11 No.1, pp. 7–31.

Roxas, S. A., Piroli, G. P. and Sorrentino, M. (2011) 'Efficiency and evaluation analysis of a network of technology transfer brokers', *Technology Analysis and Strategic Management*, Vol. 23 No.1, pp. 7–24.

Rubin, H. J. and Rubin, I. S. (2012) *Qualitative Interviewing : the Art of Hearing Data*. Edited by H. J. Rubin and I. S. Rubin. Thousand Oaks, CA: Sage.

Saldaña, J. (2009) *The Coding Manual for Qualitative Researchers*. Los Angeles: Sage.

Spithoven, A., Clarysse, B. and Knockaert, M. (2011) 'Building absorptive capacity to organise inbound open innovation in traditional industries', *Technovation*, Vol. 31 No.1, pp. 10–21.

Tan, A. R., Matzen, D., McAloone, T. C. and Evans, S. (2010) 'Strategies for designing and developing services for manufacturing firms', *CIRP Journal of Manufacturing Science and Technology*, Vol. 3 No.2, pp. 90–97.

Tran, Y., Hsuan, J. and Mahnke, V. (2011) 'How do innovation intermediaries add value? Insight from new product development in fashion markets', *R and D Management*, Vol. 41 No.1, pp. 80–91.

Tsang, E. W. K. (2013) 'Generalizing from Research Findings: The Merits of Case Studies', *International Journal of Management Reviews*, Vol. 16 , pp. 369–383.

Van de Ven, A. H. and Huber, G. P. (1995) 'Introduction', in Huber, G. P. and Van de Ven, A. H. (eds) *Longitudinal field research methods; Studying processes of organizational change*. Thousand Oaks, CA: Sage, pp. vii–xiv.

Van de Ven, A. H., Polley, D., Garud, R. and Venkataraman, S. (1999) *The Innovation Journey*. Oxford, UK: Oxford University Press.

Van de Ven, A. H. and Poole, M. S. (1995) 'Methods for studying innovation development in the Minnesota innovation research program', in Huber, G. P. and Van de Ven, A. H. (eds) *Longitudinal field research methods; Studying processes of organizational change*. Thousand Oaks, CA: Sage, pp. 155–185.

Verganti, R. (2008) 'Design, Meanings, and Radical Innovation: A Metamodel and a Research Agenda', *Journal of Product Innovation Management*, Vol. 25 No.5, pp. 436–456.

Yin, R. K. (2014) *Case Study Research, 5th Ed.* 5th edn. Thousand Oaks, CA: Sage.

Appendix A- List of interviews

#	Date	Stakeholder	Purpose
1	25/03/2014	MARCOD	Business consultant and main facilitator of the project Læsø Green Ferry between August 2013 and May 2014
2	28/05/2014	Frederikshavn Business Council	Project facilitator during 2010
3	28/05/2014	Frederikshavn Business Council	Project facilitator between January and June 2011
4	16/06/2014	Læsø ferry	Ferry company technical officer, involved during the whole life cycle of the project 2010-2014
5	16/06/2014	Læsø ferry	Ferry company director 2013-2014
6	12/06/2014	Electronics and controlling equipment supplier	Firm involved in the development of the energy monitoring system (SEMS)
7	22/05/2014	Refrigeration firm	Firm involved in the retrofit of the HVAC system
8	03/06/2014	Metal work and electrical maritime and offshore supplier SME	Local supplier involved in the project during 2010-2011. Proposed LED lighting retrofit and installed samples in the ferry car deck
9	03/07/2014	Metal work SME	One of the local SMEs that initially showed great interest in the project but after some months decided to step down.
10	01/07/2014	MARCOD	Main facilitator of the project between January 2012 and May 2013. Among other functions, was the main motivator to start the energy monitoring system

Figures

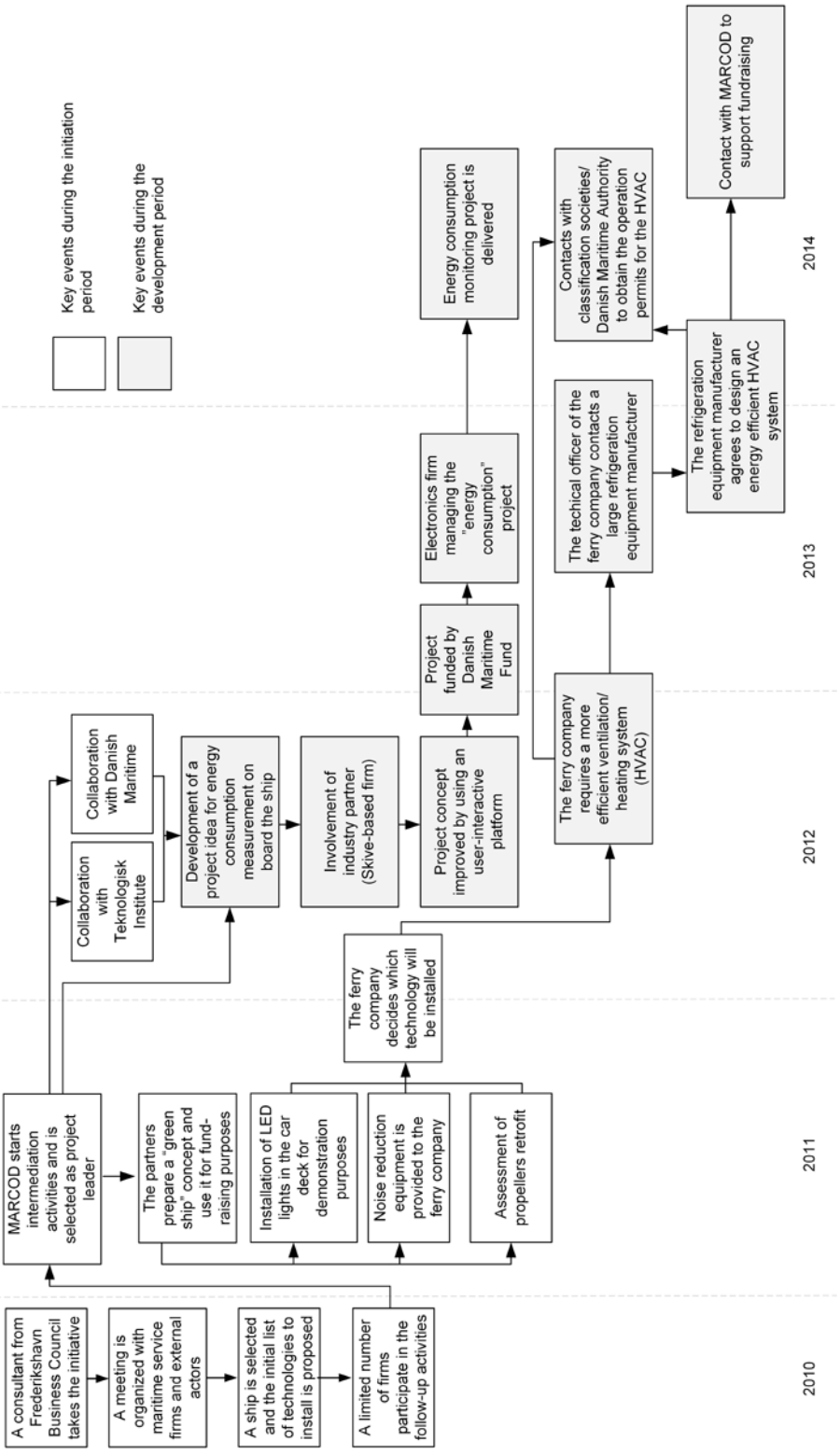

Figure 1 Event diagram of the project green retrofit of the Læsø ferry. The function of intermediaries is analysed in the initiation and development periods. The squares represent the main events of the projects.

Initiation		Development	
Foresight and forecasting	• Foresight about regulatory push in the shipping industry: sulphur regulations on fuels • Forecasting new products/ services to respond to the demand rising from this new regulation	Knowledge recombination	• The consultant from the intermediary organization MARCOD used his previous knowledge to propose the project SEMS
Scanning and information processing	• Filtering technical options for the demonstration project • Scoping the project	Brokering	• Intermediaries provide potential solutions for a SEMS prototype • Intermediaries select the solutions and partners • Finding a third party approver for the HVAC system
Brokering (Collector)	• Collecting proposals of ships where the demonstration project could be developed • Collecting more specific technical proposals • Elaborating a detailed budget	Increasing connectivity	• Invite relevant external partners • Defining partner role in the development of SEMS • Fundraising
Broad networking	• Organizing maritime business conference • Initial idea of a 1:1 scale demonstration: the green ferry retrofit	Following up adhoc groups	• Orchestrating adhoc group activities • Following up initial commitments
Setting up adhoc groups	• Inviting to open meetings where several suppliers participate • Organizing an in situ visit on board the vessel • Preparing a catalogue of technology to be installed in the demonstration project		

Figure 2- Functions of intermediaries in the demonstration project "Læsø green ferry"

Tables

Table 1- What is a "green" retrofit. Products and services initially offered by firms interested to participate in the consortium

Firm	Number of employees	Proposed product/ services
Læsø ferry K/S	10-15	• Docking and vessel
MAN Diesel & Turbo	>500	• Upgrading current engines to Tier II • Installation of Humid Air Motor (HAM) to reduce NO_x formation • Shaft generator with fluent frequency • Optimization of propellers • Improvements of the speed pilot • Optimization of gear steering • Gas operation
Norisol	>500	• Calculation of heat loss • Installation of flue exchange in the exhaust system • Optimization of insulation in the technical installations
RM Staal A/S	<10	• Installation of NO_x reduction system
Scanel International	>250	• Inspection, measurements and survey report • Illumination hardware • Energy optimization of the lighting system, HVAC and Cooling systems • Control systems
Elektromarine	>100	• Energy monitoring devices, frequency monitoring, electrical switchboard
Silentor	<10	• Noise reduction
Thorø Industry & Skadeservice	50-200	• Cleaning of ventilation ducts
Industrial Refrigeration firm - Aarhus (*)	>10 000	• HVAC system
Electronics firm - Skive (*)	>500	• SEMS (Ship Energy Management System)

(*) No real name

Table 2- Intermediary organisations involved in the project Læsø Green Ferry

Organisation	**Frederikshavn Business Council (Erhvervshus Nord)**	**Maritime Centre for Operations and Development (MARCOD)**
Period of time facilitating the project	End of 2009- summer 2011	Summer 2011-2014
Type of organisation	Public/ private association supporting local firms in the municipality of Frederikshavn, including the harbour cities of Skagen and Sæby.	Public/ private knowledge and consultancy centre established in 2011 as a non-profit organisation with seed funding from public and private grants.
Activities	The Council has eight business consultants who provide different kinds of services to the member SMEs within the municipality. These services include coaching on entrepreneurship, management and markets.	The centre supports individual maritime service industries, for example, one-to-one sparring on developing new products, services and markets. MARCOD also supports maritime networks in Northern Denmark harbours; these services include among others the projection of joint R&D and market projects.

Funding	Membership fees The Business Council also receives public funding from the Danish State and the European Union to carry out different kinds of applied projects which aim to create growth in the local economy, but are not tied to a specific sector, among others entrepreneurial women projects and fisheries market and product improvement.	Public and private grants –i.e. large maritime firms, regional authorities.