

Accelerating Acquisition in an Open Innovation Ecosystem

Completed Research

Håkan Burden

RISE Viktoria & University of Gothenburg

hakan.burden@ri.se

Sandra Haraldson

RISE Viktoria

sandra.haraldson@ri.se

Mathias Karlsson

RISE Viktoria

mathias.karlsson@ri.se

Niklas Mellegård

RISE Viktoria

niklas.mellegård@ri.se

Eddie Olsson

RISE Viktoria

eddie.olsson@ri.se

Abstract

In order to realize the potential of open innovation, a purposive transfer of knowledge between the established actors and potential new service providers has to be established. We have addressed the challenge by applying a sequence of innovation intermediaries involving actors from the local port and students from three bachelor programs. The outcome manifested itself in the acquisition of both tacit and encoded knowledge and served as a milestone in establishing a standard within maritime IT.

Keywords

Maritime ITS, Coupled innovation, Student-industry collaboration, Open innovation intermediaries

Introduction

Maritime transports are to be regarded as a self-organized ecosystem (Kay et al., 1999) characterized by sub-optimization where historically each actor to has optimized its own operations, often giving rise to inefficiencies as a whole. In recent years however, digital transformation has challenged this by providing means for enhanced transparency in data sharing and situational awareness, enabling better coordination and improved efficiency on the whole (Lind et al. 2018a). Digital transformation drives the possibilities of creating new value by enabling higher degrees of connectivity between actors, digitally twin physical objects, drawing patterns of behaviour based on extensive sets of historical data, as well as harmonizing data sharing through standardized interfaces and communication protocols (e.g. Almirall and Casadesus-Masanell 2010; Gassman et al. 2010; Lakhani et al. 2006). To break existing patterns of behaviour and to avoid the creation of proprietary solutions that feed sub-optimization, there is a need for new inspiration and perspectives that capitalize on the opportunities that digital transformation provides. From an open innovation point of view, this means that innovators both having experience from the sector as well as from other sectors would come together, come up with, and provide new applications not previously possible or never thought about before. A core capability that the ecosystem needs to develop and ensure is data streams made accessible for those that can provide new applications aimed for the single actor and/or clusters of actors, within or outside the maritime sector (Lind et al. 2018).

This has also been one of the objectives for Port Collaborative Decision Making (PortCDM), which is a concept that provides guidelines and standards for the data exchange within and between ports, between ships and ports, and between ports and hinterland operators (Lind et al 2018). Such data exchange is necessary if enhanced efficiency during port call operations is to be achieved but also facilitates open

innovation within the maritime sector. In order to realise that potential, a purposive transfer of knowledge between the established actors and potential new service providers has to be established (Chesbrough 2006). We therefore set out to explore *How can open innovation intermediaries accelerate acquisition in an ecosystem through the management and throughput of knowledge transfer?*

We address the question through a longitudinal study by applying an action research approach involving actors from the local port and students from three bachelor programs. Before we describe the specifics of the research methodology, we outline our theoretical framework in terms of how knowledge transfer can be framed within an open innovation ecosystem. After the research methodology we detail the five iterations and then discuss the effect on knowledge transfer within the ecosystem. Finally, we conclude and give directions on future research.

Theoretical Framework

Influenced by Smith et al. (2016), we analyse the interventions in an open innovation ecosystem in terms of knowledge transfer between the inside (the local port) and the outside (the university students) in both the social and technical dimensions. A graphical representation of the framework is depicted on the left side of Figure 1. Smith et al. derived the framework from their work with an innovation contest. They concluded that the contest generated substantial knowledge transfer during the execution but without persistency, when the contest was over the transfer terminated to.

Socio-Technical Eco-Systems

The term socio-technical system is used to analyse the interaction between people and technology at work places (Emery and Trist, 1960; Dubin 1970; Boström and Heinen 1977). The term has been enhanced over the years to include digital technologies (Mathews, 1997), systems engineering (Baxter and Sommerville, 2011) as well as formal regulations and social norms to keep up to date on how humans and machines interact (Geels, 2004). Here we use the term to capture both the involved actors, the social system, and their digital resources, the technical system. Innovation ecosystems can be viewed as socio-technical systems with a focal product as center for the technical development which is governed by a focal consortium (Adner 2006; Adner and Kapoor, 2010). From such a viewpoint, Smith et al. (2016) define the external innovators as distributed complementors who contribute with distributed complements to the focal product. The reason for innovation seekers and external partners to collaborate varies across collaborations, depending on factors such as locus, knowledge of the actors and incentives (Chesbrough and Bogers, 2014). The form of interaction between the social and the technical systems on the outside and the focal product and consortium on the inside determines the nature of the ecosystem.

Coupled Open Innovation

Open innovation implies that knowledge is transferred between the innovation seekers and the outside world and can subsequently be classified in terms of three distinct forms - inbound, outbound and coupled innovation (Grassman and Enkel, 2004). Inbound innovation is characterised by the innovation seekers complementing their internal innovation capability by that of the outside (Enkel et al, 2009). Outbound innovation is subsequently the opposite, where the innovation seekers provide access to internal resources so that outsiders can innovate with them (Grassman and Enkel, 2004). The third form, coupled innovation, refers to joint development in which both the innovation seekers and the external partners share the benefits of creating innovative products and services (Grassman and Enkel, 2004).

Knowledge can be both tacit and explicit. Explicit knowledge is coded in writing or symbols and can be transferred as separate entities; tacit knowledge resides within people and has to be acquired through human interaction (Polanyi, 1966). As the importance of digital information has grown with the impact of information technology, the role of encoded knowledge has been recognised as a specific kind of explicit knowledge since it encompasses the technical dimension in terms of the source for websites, databases and mobile apps (Blackler, 1995; Warhurst, 2013), representing knowledge within the technical system.

Facilitating knowledge transfer is thus a key factor for a successful ecosystem (Roux et al., 2006) and a prerequisite for coupled innovation is the knowledge transfer between the inside and the outside (Hamburg, 2011). Within a socio-technical system, tacit knowledge transfer is managed by the interaction

between people. For open innovation to occur this has to be managed so that those inside and those outside can interact. This is seen as harder to accomplish than transferring explicit knowledge since it requires inter-personal meetings (Osterloh and Frey, 2000). In contrast, explicit knowledge can be shared through the technical dimension (e.g. as source code or documentation) or through the social dimension.

Open Innovation Intermediaries

Innovation intermediaries facilitate innovation by either directly interacting with a specific innovation seeker or indirectly enhancing the innovative capability of a region or sector (Dalziel, 2010). An intermediary involved in open innovation is thus an entity who helps in coupling focal consortia with complimentary developers by establishing networks and representing a single and neutral point of contact (Hallerstede, 2013; Lopez-Vega and Vanhaverbeke, 2009). The intermediary can also facilitate open innovation by providing knowledge and capabilities that the other partners are lacking or technological resources in terms of platforms, regulations, standards and implementation advice (Lopez-Vega and Vanhaverbeke, 2009). Key aspects for successful intermediaries in an open innovation ecosystem is establishing trust among the participating parties (Porto Gómez et al. 2016) and taking an active role (Smith, 2018). Such key aspects are necessary to enable open innovation in a self-organized ecosystem e.g. the maritime domain. The role of the intermediary has also been described as a knowledge broker (e.g. Almirall and Wareham, 2008; Frey et al. 2011). By emphasising the aspect of knowledge transfer the role of the broker is to map ideas to potential implementations (Winch and Courtney, 2007). Or, in terms of our theoretical framework, coupling the inside with the outside as well as the social dimensions with the technical dimensions within an innovation ecosystem (Smith et al., 2016). The intermediary does not have to be a specific person but can be an organisation such as an incubator (Lopez-Vega and Vanhaverbeke, 2009) or a process (Smith et al. 2016) such as an innovation contest (Hjalmarsson et al. 2014).

The Ecosystem

In terms of the theoretical framework the model is instantiated so that a local port consortium represents the social dimension of the inside while PortCDM is the technical side. The outside is then represented by students from two different universities and their applications, see the right side of Figure 1.

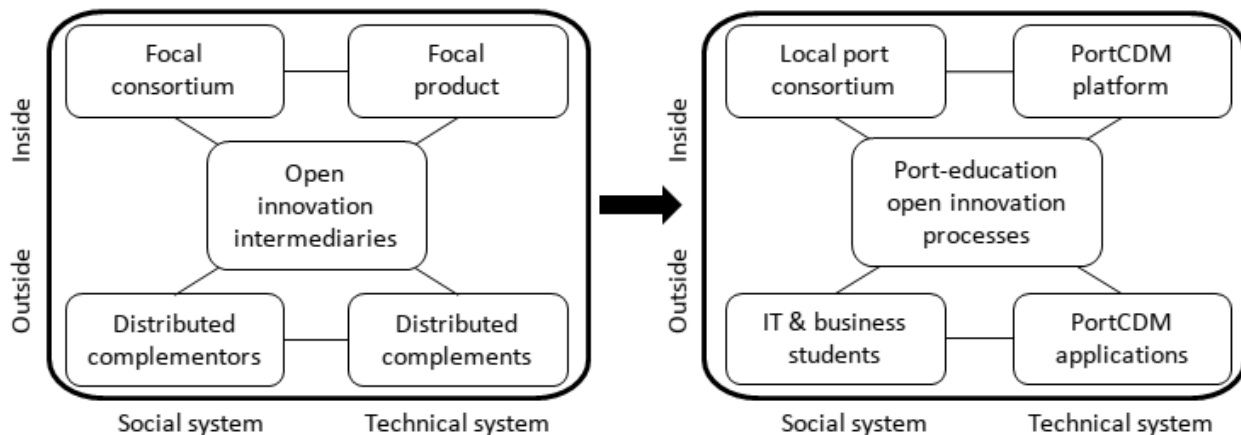


Figure 1: The theoretical framework, to the left, and its instantiation, to the right.

The Local Port Consortium

The EU-funded Sea Traffic Management Validation project (STM, Lind et al. 2018a) aimed to provide safer, more efficient and more environmentally friendly maritime transportation. One of the outcomes of STM is PortCDM, which concerns improving the predictability of port operations by sharing the planned intentions and actuals of their operations to provide the involved actors with a common situational awareness. In order to capture the information needs of the local stakeholders, each port involved in the project forms a consortium in the form of a living lab (Almirall and Wareham, 2011) which have been co-

producers of the PortCDM concept and later on validators of the PortCDM implementation. The role of STM was thus to actively manage the transition through the phases of initiation and definition into demonstration and validation. In parallel, the ambition is that emerging commercial opportunities will encourage new and established actors to drive large-scale uptake.

In 2015 work began on implementing a first version of a platform, PortCDM v.1.0, for sharing real-time data of estimates and actuals of arrivals and departures from different locations in a port and when operations are commencing and completed. Each port has its own backend instance for data exchange. The backend is accessed through open APIs so that existing IT-systems can submit and subscribe to data relevant for their operations without having to introduce yet another system. In our study the local port consortium from the port of Gothenburg participated and a clone of the Gothenburg PortCDM instance was used as focal product. This meant that the complementary developers could see the data the actors in the focal consortium exchanged through the platform without risk of manipulating it.

The IT and Business Students

The majority of the innovation seekers came from the Software Engineering Project course, which is taught within a number of bachelor programs with IT as a major or minor specialisation. The course represents 7.5 ECTS, equivalent to five weeks of full-time studies. It is given over ten weeks so that each student is expected to work 20 hours a week, including lectures and reading literature. The project scope is defined by the teachers together with one or more external stakeholders (the focal consortium) so that the students have to plan, implement and evaluate a project where they do not own the definition of value (Stegh fer et al. 2018). The aim is that the students will understand basic concepts of software engineering and can reflect on the relationship between stakeholders, processes and produced value.

The course is structured so that the first three weeks is devoted to introducing the project-relevant foundations of software engineering through lectures and exercises. The following six weeks are devoted to project work where the main interaction between students and teachers occurs during weekly supervision. The supervision serves three purposes: in interaction with the teachers the teams get the opportunity to reflect on their process and learning; in interaction with the consortium the teams get to negotiate the scope of their complement; and finally, in interaction with the other teams, students manage inter-team dependencies. The course ends with a final presentation where all involved can see the outcome of the project. In the final week the students write a reflection report on their experiences.

The Open Innovation Intermediaries

The different collaborations between the local port consortium and the students serve as innovation intermediaries. Each intermediary had distinct start and end dates, different activities to promote knowledge transfer and co-creation, a specific purpose with defined roles and responsibilities for those involved and can thus be seen as processes according to Juell-Skielse et al. (2014). What differs among the intermediaries is the format, as we applied the concept to collaborations on the project element of a course at two different occasions, a bachelor thesis project and twice as internships.

Our role in the ecosystem was as researchers facilitating the living labs, as architect and scrum master in developing the PortCDM platform and as the course responsible in the Software Engineering Course. We were all employed by the same research institute and thus represent one point of contact when setting up the intermediary processes. It also meant that we were active in all three formats so that both the context of the focal consortium and that of the complementary developers was represented simultaneously in the intermediary process. Two of the intermediary formats were initiated by the focal consortium, while one format was initiated by the complementary developers.

Research Design

We complement the static theoretical framework by applying a participatory action research approach (Baskerville, 1999; Lewin, 1946) so that the overall research process becomes a chain of changes to the innovation ecosystem. Action research is conducted over a series of iterations where each iteration can be broken down into three steps – planning, acting and reflecting (Dickens and Watkins, 1999). Planning, as defining the goals of the action, setting up the organization that will carry out the change and acquire the

necessary permissions, knowledge and skills; Acting, as executing the plan and collecting the data that reflects the change. The data can consist of interviews, surveys, logs and/or observations but also artefacts such as documentation of the decisions that are made and products together with their rationale. Reflecting, as evaluating the impact of the change in terms of collected data, discussing the organization and process with the participants, analysing the collected data as well as communicating the results to the relevant audiences. We are not interested in each single e-mail, conversation or formal meeting between or among the intermediaries, the consortium members or the students. Collecting all that data would be close to impossible since the teams chose and own their own tools and organisation for the project while we cannot have access to all the interaction among the consortium members due to confidentiality reasons. Instead, we treat the distributed complementors as an entity by itself, just as we do with the consortium and the intermediaries. We also abstract away from the everyday details of the interaction and focus on the overall outcome in terms of impact on knowledge transfer before and after an iteration. In this way our iterations represent stable states in terms of knowledge transfer while the interventions are explicitly tailored to transition from one state to another.

The Open Innovation Intermediaries

The format of describing the intermediaries follows the theoretical framework in that we describe each intermediary as consisting of the motivation for a specific intervention, the execution of the intervention, and the outcome in terms of created changes and of knowledge transfer. The state of the system before the first port-education collaboration is depicted in the top-left corner of Figure 3 and given the number one.

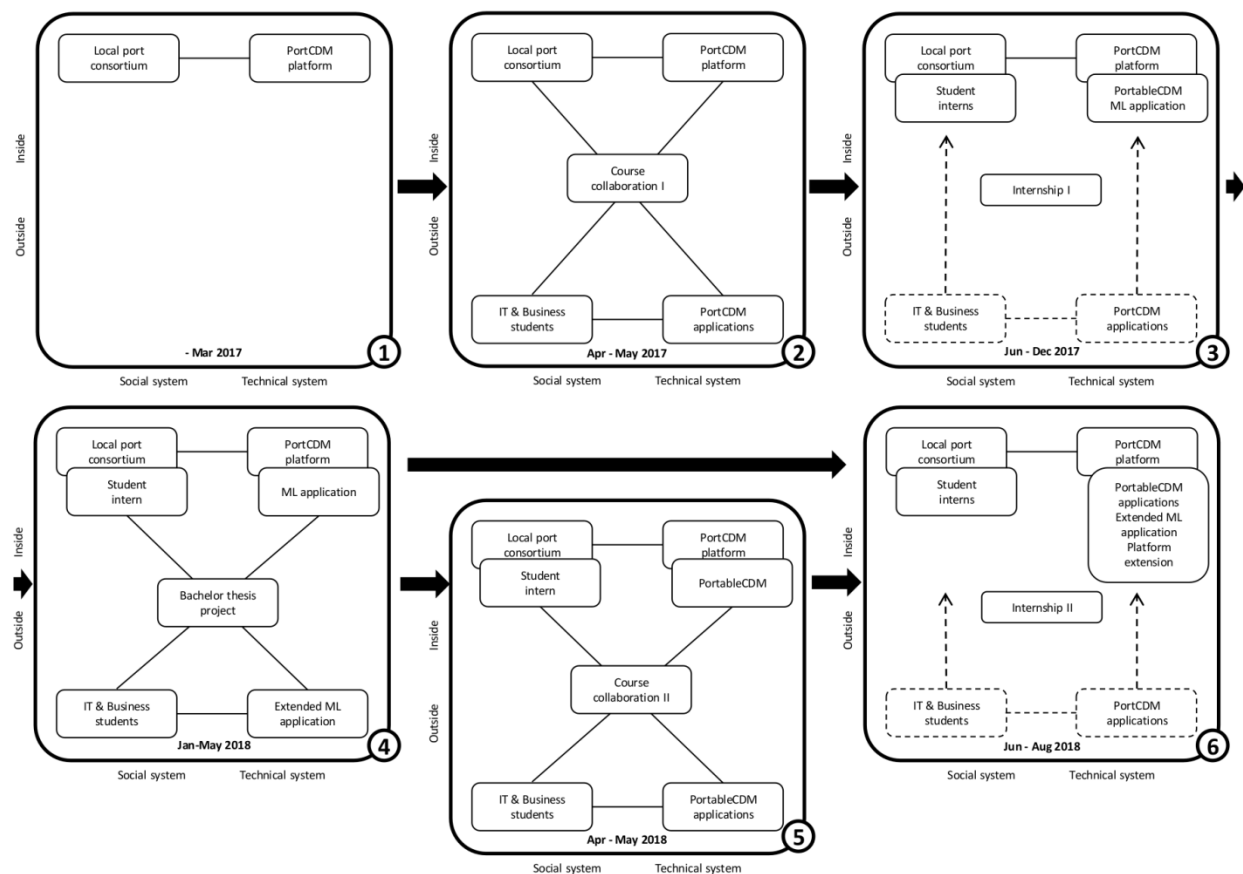


Figure 2 The intermediaries shown as knowledge transfer within the ecosystem.

Intermediary I - Course Collaboration I

Motivation: While the work with the local living labs and implementation of PortCDM is an interesting story in itself, there was no activity on the outside, see state 1 in Figure 3. In order to validate the

appropriateness of the emerging standard as well as the suitability of the corresponding APIs and tool chains for open innovation, it was desirable to study how complementary developers could develop new applications on top of the PortCDM platform.

Execution: Through our dual roles as researchers in the living labs and as University teachers we could set up a course instance in the spring of 2017 with 58 students from three different bachelor programs: 47 students were in their last term in the IT business management program; seven students in the second year of the Computer science program; and four students in the second year of the Computer engineering program. Together they formed ten teams. We assigned a port actor to each team and asked them to develop an application relevant for their actor. Each week included a supervision slot where the teams met consortium representatives. The student teams also received a scenario from the consortium which described a typical port operation and a lecture introducing the business case for PortCDM and an overview of the platform. Each team also got a point of contact and to visit a workplace so they could see their actor in a real setting. At the final presentation the students pitched their applications and then demonstrated them live in front of the local port consortium. The teams also received technical support for how to send and receive data on the PortCDM clone.

Outcome: All ten teams were capable of delivering a working application that fulfilled their specific actors' information needs. The applications and the subsequent data sharing were demonstrated by the teams going through a new scenario with different operations and timings than the one that was handed out at the start of the collaboration. This meant a transfer of knowledge from the inside to the outside in terms of maritime value creation as well as support with the technical platform. In the opposite direction the students provided novel ideas, programming skills and new applications encoding their contributions (see the second state in Figure 3). The students incentives for the collaboration were non-pecuniar and as they were not reimbursed for their work they owned the outcome in terms of distributed complements. The knowledge transfer within the consortium and the role of the innovation intermediaries for establishing the consortium are out of scope in this contribution.

Intermediary II - Internship I

Motivation: During the course collaboration in the spring of 2017, state 2 in Figure 3, the project team saw the capability and the opportunity in the different applications the students were developing and decided to offer students interested in continuing to work with PortCDM an internship during the summer, see state 3 in Figure 3. The internship was presented to the students during the penultimate supervision slot.

Execution: Four students were hired for an internship, June to August 2017, and were divided in two working pairs: one pair focused on developing a generic application suiting different actors in the maritime consortium, which could be used in the eight different PortCDM test-beds throughout the rest of the STM validation project. The other pair focused on developing a model for machine learning, where different data sets were used to calculate and support the actors perception on estimates for when a ship could depart from a quay. The internship started with a startup meeting between product owner, the PortCDM concept group, and the students where ideas and expectations was presented on what the students should create and achieve during the period.. Throughout the internship the product owner and the students had weekly Monday meetings to plan the work week and a Friday follow up meeting to discuss weekly progress.

Outcome: The internship ended up in one generic PortCDM mobile application, PortableCDM, available on both iOS and Google Play store, to enhance the possibility to coordinate port calls. The application was built to give users an easy access to monitor and update forthcoming and present port calls in a port. By selecting a port call users can report new timestamps to selected port call and get a common situational awareness of the port call (Lind et al. 2018a). PortableCDM has been used in the different test-beds during the project. A data quality service to inform users of the level of accuracy of reported time stamps from a particular source based on machine learning, which becomes better over time and where models are being trained by supervised learning, was also a result delivered by the students in the internship.

An important distinction between the internship and the course collaboration is that by employing the students as interns we could now acquire the distributed complements, thus acquiring both tacit and encoded knowledge to the local port consortium. Two of the students also stayed on after the internship to work part-time on further developing the applications.

Intermediary III - Bachelor Thesis Project

Motivation: One of the students from the internship, which continued to work part-time after the internship saw an opportunity to continue work with and study the machine learning application developed during the summer and presented an idea of a Bachelor thesis together with four other students to the project team, see state 4 in Figure 3.

Execution: During the spring of 2018, the Bachelor thesis project about Port Call Synchronization started and was tutored by the project team. The scope of the Bachelor thesis was to build and evaluate a proof-of-concept service for port call synchronization based on machine learning to show how synchronization possibly could be done automatically if digitalization is pushed forward.

Outcome: The students produced a proof-of-concept service for Port Call Synchronization accessible via a web interface was created during the bachelor thesis project. The service was used to test to automatically generate recommended time of arrivals (RTA) for ships on a voyage to a PortCDM port, based on machine learning and data from the PortCDM instance in the port. An elementary quay optimizing system was also developed and tested, based on the automated Port Call Synchronization service.

Intermediary IV - Course Collaboration II

Motivation: As a result of the positive response from students in the course collaboration I, the value the project team saw of the outcomes from course collaboration and the positive response from the local port community a course collaboration II was organized, see state 5 in Figure 3.

Execution: During the spring of 2018, we taught 82 students from three same bachelor programs as in encounter I. Together they formed eleven teams. The teachers assigned an external stakeholder to each team, which was then tasked to take the generic PortableCDM application, created by the summer interns from 2017 and refined by the interns that worked part-time after the summer and develop a stakeholder-specific application. During this course collaboration, the student who initiated the bachelor thesis project participated as a consortium representative by supervising the student teams with technical support.

Outcome: The course collaboration ended up in ten different specific PortCDM mobile applications that fulfilled their stakeholders' information needs. to enhance the possibility to coordinate port calls. The applications and the subsequent data sharing were demonstrated by the teams in an open mingle event with the stakeholder representatives invited where they could walk around and get demonstrations of the different applications from the student groups.

Intermediary V - Internship II

Motivation: Based on experiences from course collaboration I, see state 2 in Figure 3, and the success of the summer internship, see state 3 in Figure 3, the PortCDM project team already knew they wanted students for internships during the summer 2018 and was using course collaboration II, see state 5 in Figure 3, during the spring of 2018 to find students interested in a summer internship. The internship was addressed to the students during the second half of the course.

Execution: Nine students was hired for an internship, June to August 2017. They were divided into different working groups to build different actor specific PortCDM applications based on the generic PortableCDM application created the year before, see state 3 in Figure 3, with inspiration from the applications built in course collaboration II, see state 5 in Figure 3. The work of the summer interns were led by one of the students that been working part-time on PortableCDM with support from the product owner, the PortCDM concept group, which also had weekly Monday meetings with them to plan their work week.

Outcome: The internship ended up with for different PortCDM mobile applications available on both iOS and Google Play store (Lind et al. 2019a): *Portable Captain*, with the purpose of providing a ship's captain with situational awareness of port calls about to be conducted. *Portable Agent*, with the purpose of providing the agent with situational awareness for the port call that the agent is involved in. *Portable Services*, with the purpose of providing the service provider with situational awareness for the port call that the service provider is involved in. *Portable Berths*, with the purpose of providing the terminal operator with situational awareness for the port call that the terminal is affected by (Lind et al. 2018a).

Those applications have been available and used by the actors in the different test-beds during the PortCDM project. Three of the students continued to work part-time during the fall of 2018 with the applications brought forward during the summer. Just as for the first internship, the hiring of the students enabled the local port consortium to acquire both their tacit and encoded knowledge.

Discussion

So, returning to our initial research question *How can open innovation intermediaries accelerate acquisition in an ecosystem through the management and throughput of knowledge transfer?*, we can see that a difference in relation to Smith et al. (2016) we actually went beyond creating knowledge transfer, we managed to acquire the new knowledge in a chain of encounters.

Our way of organising the collaborations and setting up the intermediaries is one answer to the needs seen by Perkman and Walsh (2007) who see potential in students engaging in open innovation but lack a reasonable format. In our framework the role of the intermediary as a knowledge broker is key since information as such is not easily transferred between different actors (Polanyi 1966). During the weekly supervisions substantial time was spent on explaining what the different port actions represented and how they mapped to PortCDM concepts so that the students knew which timestamps to use and for what purposes. A key enabler for providing meaningful supervision was to couple the innovation intermediary process to establish trust in both the inside and the outside of the ecosystem (Porto Gómez et al. 2016). By including a research institute responsible for organising the living lab and teaching at two universities in the local port consortium there was an organisation that could effortlessly move between the inside and the outside of the ecosystem, facilitating both the inside's and the outside's need for a single point of entry. This ensured that the same information was provided to everyone and that the same technical platform was supported for all teams.

The setup required coordination so that the researchers and teachers shared common goals and aligned their actions. The researchers had access to the project consortium reaching out to the living lab participants allowing them to try the new innovations. This required that the students provided applications to be put into test in due time and that the users committed to testing and providing feedback to the students. At the same time, the students' educational tasks and efforts needed to be respected while ensuring that the different actors acquired value from the collaboration. The student participation in the PortCDM innovation process has enabled validation of the standard for data sharing developed in the research project. The ability of distributed complementors to create value in such a short time span without prior knowledge of the maritime domain gave PortCDM credibility in the eyes of the port actors. The data exchange format has from that point, with the students input as one source of validation, made a transition from a project exchange format (PCMF) to an internationally recognized standard (S-211). Another contribution from the student participation was the validation of the interfaces for third party innovation based on the PortCDM platform. The objectives for the project have been to lower the barriers for such development, which the students have contributed to and confirmed through their participation. To this end the students represent the extreme end of complementors as they have no ties to old maritime habits and are free to explore with fresh eyes while IT represents both an unconditional part of their own daily life and a key competence in their future professions. Here supervision also served to assess how the teams progressed in terms of delivering value to the port actors so that their exploration made sense for the focal consortium.

The overall intention with the development of PortCDM has been to develop a sustainable innovation, that survives after the end of the STM project. With that intention in mind, several incentives were taken throughout the project to ensure an uptake on PortCDM in the maritime domain. Besides the enablers already mentioned, i.e. interfaces to lower barriers for third party innovation and an internationally recognised standard for data sharing, an International PortCDM Council was established to govern and maintain the PortCDM concept. The council also has the role of securing a long-term "stability" for the PortCDM concept, ensuring that PortCDM compliant tools and principles is a worthwhile investment for users to adopt and providers to develop. In addition to this, a maturity model was developed to facilitate PortCDM compliance for future stakeholders and port instances guiding different efforts for development. Other enablers to empower PortCDM as a sustainable innovation is the Living Lab Approach, a methodology to sustain actor collaboration. The PortCDM concept is heading towards a commercial uptake in several respects. While some aspects are further developed in new project settings, other are

realized through commercial actors developing solutions founded on the concept. We aim to return to this progression in future work.

Conclusion

The interventions in each episode have contributed with the basis for the validation of two of the enabling components necessary to bring the Maritime sector to a new PortCDM reality; validation of the Port call message format as well as providing experiences from conducting third party development using interfaces from the Platform. To conclude, through the intermediary processes we have conducted five collaborations, each collaboration resulting in knowledge transfer between the inside and the outside, both in terms of tacit and encoded knowledge. One of the encounters was initiated and managed by the outside. The collaborations resulted in the recruitment of skilled interns by the inside and enabled the acquisition of knowledge not once, but twice. The student's capabilities of bringing forward the different digital innovations in a very rapid way shows that the PortCDM environment, using standardized interfaces for the provision and consumption of timestamps is an easy way to provide new digital innovation to the maritime community. The impact in terms of accelerating innovation and further analysis on other open innovation in different domains are topics for future research.

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