

How to turn an innovative concept into a success? An application to seaport-related innovation

Short title: How to turn an innovative concept into a success?

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The main objective of this paper is ‘to assess the conditions, including policy support, under which innovative concepts have a high chance of getting adopted and being successful’. The work will start from the state-of-the-art with the following goals targeted. Firstly, to identify the paths that new innovative concepts usually follow, what key determinants are, which actors are involved, and what policy has been doing and can do. As part of this, a typology of variables is established, which will be the basis for the identification of successful adoption paths. Illustrations are provided of the performance of different innovative concepts in the seaport sector. A further goal is to propose policy recommendations, identify best practices, barriers to implementation and transferability of innovative concepts and processes. Finally, the research establishes developments needed in assessment methods and a methodological framework if innovative concepts are introduced.

Keywords: seaport innovation, indented berth, port community system, cold ironing, adoption path

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1. Introduction

Innovation may happen very rapidly indeed. However, the poor innovative strength displayed by the transport sector in the broad sense often contrasts strongly with that evidenced elsewhere. A comparative study by Dialogic and NEA (2002) on behalf of the Transport Research Centre (AVV) in the Netherlands has shown the transport sector to score less than the average for the economy as a whole when it comes to innovation. Likewise in countries with a good overall climate for innovation (Finland and above all Sweden) the transport sector performs well below average.

It can be concluded from that and similar studies that quite a lot of innovative concepts in transportation have been studied in detail (e.g. Trujillo and Medda (2009), Aronietis *et al.* (2009), Kapros (2010), Gevaers *et al.* (2010), Arduino *et al.* (2011)). The main focus hitherto however has always been on inventing or introducing new concepts and procedures. Hardly ever has the innovation process as such been assessed, and have generic conclusions been drawn with respect to factors, which benefit or disbenefit the successful adoption of innovative ideas. Exceptions are Garrison (2000), who has also derived generic understandings in the relationship between innovation and transportation technologies, and Hoogma *et al.* (2002), who draws generic conclusions from the study of eight examples of innovation concepts in the field of sustainable transportation.

It is also learned from the state of the art of transport innovation studies that innovation need not be technological and, in practice, a very small percentage of innovations are. In all cases, there is a process surrounding the application of innovation, which includes the incubator, a cluster of actors supporting its application and in all instances the application of innovation leads/requires organisational change.

Taking into account the main observations from the state of the art, it is clear that innovation in surface transportation and in logistics chains, as a change producing mechanism, needs to be much further assessed and benchmarked. The main idea behind this paper is to see how focusing on improved market understanding, knowledge management and network organization can advance innovation integration in transport and logistics chains.

This paper starts from a clear definition of what is to be conceived as an innovation, which is introduced in section 2. Equally, in that section, the methodology which will be used in the further analysis will be explained. Section 3 will apply the methodology in three port-related cases. In order to get a perspective on the adoption processes of innovations in surface transport and logistics, three steps are put forward, as applied in section 3. The cases will in particular focus on seaports. Section 4 will derive generalized conclusions from the analyses made in the previous section: a typology of innovations according to common characteristics, a typology of actions under different circumstances, and a typology of factors for stimulating success factors. The final section 5 gives a set of recommendations that are to be implemented by both policy

makers and transport business actors if one wants to generate better conditions for innovation to be successful.

2. Concept definition and methodology

The first studies on innovation date back to 1911 and the seminal work of Joseph Schumpeter. The core of Schumpeter's definition of innovation is that it is an effort made by one or more individuals that produces an economic gain, either by reducing costs or through increased incomes (Smith 1998; Sundbo 1998). Schumpeter described innovation as a historic and irreversible change in the way of doing things. A lot can also be learned from the work established by Rogers (1962), which is a key reference that established innovation theory, adoption categories, influences and characteristics of innovation.

Elaborating on this, the authors within the context of specified research agreed on the following definition, as applied to transportation and logistics:

A technological or organisational (including cultural, including marketing, as a separate subset) change to the product (or service) or production process that either reduces the cost of product (or service) or production process or increases the quality of the product (or service) to the consumer'.

From the outset, two broad categorisations of innovations were observed. First, private commercial innovations: their motivation is either revenue generation or cost-reduction. Second,

public innovations/policy initiatives: their motivation is related to achieving an increase in socio-economic welfare. Moreover, the public policy initiatives seeking welfare are generally targeted on complete sectoral and trans-sectoral transport markets.

The paper approach to analysing the innovation process, which boils down to the methodology used in this paper, in section 3 is multi-layered. The distinction between commercial innovations and those seeking to increase welfare is made in the introductory layer. The second layer of the methodology involves a number of steps. At this stage the innovation is identified by its predominant component/aspect, i.e. technological, organisational, managerial, cultural or policy, though without ignoring other subsidiary aspects of the innovation. Therefore an innovation may be characterized as predominantly “technological” and also include organizational change. In addition, since most innovations are incremental and not radical, for the purposes of this paper, the analysis concerns incremental innovations⁷.

⁷ The various categorisations with respect to innovation and innovation processes are both a source of convenience and complexity. The current paper and project adopted the OECD categorisation of scale and type. More specifically:

- Incremental Innovations: They represent a small change to existing products/procedures
- Modular Innovations: They bring about a significant change in concept within a component, but links to other components or systems remain unchanged and the impact is fairly low.
- System Innovations: They integrate multiple independent innovations that must work together to perform new functions or improve the overall performance.
- Radical Innovations: They entail a breakthrough in the specific field that could change the whole nature of an industry. They could be seen as an entirely new way of solving specific problems. They establish a new dominant design and, accordingly, a new set of core design concepts that linked together create a new kind of component or system. Existing linkages among systems and organisations may be irrelevant for the implementation of a radical innovation.

With respect to the OECD definition very few innovations in transport may be characterised as “breakthrough that could change the whole nature of (the) industry”. In the 20th century, we may be considering the container and communications.

In terms of “phases”, all processes, which entail life cycle are studied in terms of (life) phases. The number of phases may vary depending on the detail required when addressing the specific topic.

The third methodology layer involves a detailed analysis of the various factors which may, and do, affect the progress of an innovation and may either enable it to move forward rapidly in terms of take-up within the sector(s) or may cause the process to slow down, or even halt, the spread of the innovation within the sector(s). In this stage, use is made of the Minnesota Innovation Research Program (MIRP) analysis of innovation and a detailed analysis of both the barriers involved in the innovation cases analysed and the support processes used to overcome these. The objective of the MIRP, developed during the period 1983 until 1990, was to provide innovation managers with a roadmap that indicates what happens to an innovation between the input and the output. The roadmap should explain how and why the innovation journey unfolds. Controlling the innovation journey, with this knowledge, should be easier for the innovation managers. (van de Ven *et al.*, 1990; van de Ven *et al.*, 2000)

In practice this third layer includes two “sub-layers” of analysis. Following the timeline of development of innovation, in the first sub-layer, the stages of the innovation process to be studied are identified based on those presented in the scientific literature: initiation, development, and implementation. In reality, the innovation process is actually a continuous process, which may be split into a further number of phases, particularly at the beginning of the innovation process⁸. The existence of these phases of the process implies also that it is often difficult to

⁸ Previous studies show that the innovation process is continuous. Obviously for analytical purposes, it was split into a number of (supposedly) discrete phases. It could be three or five or ten. The number is dependent on the practical exigencies of analytical process adopted. The InnoSuTra project followed the MIRP three-fold division. It was suggested that the Initiation phase could be further split into a pre-Initiation / conceptual phase. Hence, a four-phase separation could be suggested.

suggest that an innovation has failed and, for most of the cases studied, the designation ‘not yet a success’ is preferable. The second sub-layer involves identifying the barriers placed in the path of the innovation and the support processes used to overcome these barriers. These barriers may be of various types and scale and may occur at different stages of the innovation process. The task is to determine in each case, or classes of cases, which factors enabled the desired progress to be made.

The fourth layer of the methodology involves the use of the Systems Innovation (SI) analytical framework. The SI approach has its roots in the evolutionary theory (Nelson and Winter 1982) and since its emergence in the early 1990’s, it has attracted the interest of policy makers, especially international policy think-tanks such as the OECD (Mytelka and Smith, 2002). This framework provides a means to identify a set of external factors (the so-called ‘institutional environment’ and ‘rules’) and the ‘sets of actors’ involved in the innovation being analysed. This layer also identifies for each innovation a ‘range of influences’. This suggests for any innovation there are likely to be influences or impacts, which extend the nature of the innovation, e.g. involving organisational or cultural components to an innovation, which has been defined, primarily, as a technological innovation. Defining all of the components of the innovation is important as the focus of attention and intervention may alter as the innovation moves through the process from initiation to implementation. In other cases it may be relevant to determine whether the initial impact of the innovation is the specific business unit involved or whether a wider market focus was involved. Finally, the role and importance of the initiator of the innovation is explored. Woolthuis *et al.* (2005) proposed a System Failure Framework (SFF) for innovation policy design by suggesting a matrix representation of Actors and Institutions where

system failures could be identified. Two basic improvements to the SFF were adopted in this analysis: the introduction of temporal frameworks representing the stages of development as proposed by Roumboutsos *et al.* (2011) and the illustration of both positive and negative correlations as opposed to only negative correlations of the System Failure Framework.

The analysis of cases that follows focuses on the fourth layer of analysis as it incorporates all previous layers of analysis. The selected cases in this paper are extracts from a more extensive, equilibrated set of 23 cases, involving further road, rail, inland navigation and maritime applications, with a broad coverage of technological, managerial, organisational and cultural as well as public policy cases⁹. Their overall selection was done based on a literature review phase supplemented with expert consultation and an in-depth two-day meeting and discussion session.

3. Analysis of selected port cases

Three port-related innovation cases are analysed: An indented berth; the application of a port community system; and the case of cold ironing. The study does not consider whether these cases are overall successful or not. The emphasis is on identifying processes and interactions that have positive and negative effects on the process. The methodology depicted in section 2 is followed, with an extended application of the fourth layer of analysis, which is based on the Systems' Innovation Framework. The analysis is constructed by mapping at the various stages of

⁹ The entire process of the selection and analysis of the 23 cases was conducted with the consortium of authors of this paper during 2010 and 2011 as part of the European FP7-funded research project InnoSuTra (www.innosutra.eu)

innovation deployment the relationships between actors and innovation factors. The findings of the first three layers of analysis, which are required in order to conduct the final one, are presented briefly in the cases' background. The data to conduct the analysis, in all cases were collected through in-depth desk research and on-site interviews.

3.1 Case 1: Indented Berth

3.1.1 Background

The indented berth is a particular berth capable of serving ships from both sides. It is identified as mainly a technological innovation, with clear managerial, organisational and cultural features. The Ceres Paragon Terminal in Amsterdam is the first terminal in the world to have an indented berth, where containerships can be loaded and unloaded on both sides simultaneously, whereby the turnaround time is almost halved in comparison to other global port terminals.

The Ceres Paragon Terminal has materialized as a joint-project of the American terminal operator Ceres Inc. from Wheelawken (USA) and Amsterdam Port Authority (APA, on behalf of the Amsterdam Municipality). The main reason was to boost the container traffic in the Port of Amsterdam, whose throughput mainly consisted of different types of bulk (coal, iron ore, agribulk, neobulk) cocoa and mineral oil products. In the Lease Agreement between APA and

Ceres, it was stated that APA would develop the civil engineering infrastructure of the terminal, and that APA and Ceres would jointly purchase the cranes and the terminal equipment.

In 1996 Ceres and APA decided to develop this new container terminal along the Amerikahaven/Noordzeekanaal berth of the Port of Amsterdam. The tender procedure followed the European Commission rules, but was dovetailed into the design process in such way that there was hardly any discontinuity. The construction contract was awarded to the combination ComPACT (comprising Van Oord ACZ, De Klerk Werkendam, Ooms Avenhorn, GTI and BemoRail) and the construction period was only 14 months. The final contract value was approximately € 50 million, divided over the key components of the contract as follows (Ligteringen *et al.*, 2002): quay walls 34% of the costs; dredging and bottom-protection 8%; drainage and pavement 41%; powers supply and utilities 8%; crane rails and rail terminal 9%.

In 2001, the terminal was delivered after two years of work on design, construction and installation. In September 2002, the Japanese shipping company Nippon Yusen Kaisha (NYK) acquired the American Ceres Terminals Inc. along with 50 percent of the shares in the Ceres Paragon Terminal. Three years after its start up, in 2005, the terminal had not served a single contract client since it became operable. This first period of NYK management can be considered the initiation phase of the indented berth¹⁰. At the end of 2008 Hutchison Port Holdings (HPH), the world's largest container terminal operator, acquired the control of the Ceres Paragon

¹⁰ NYK could not direct her own ships to the terminal, because the company operated as part of the Grand Alliance, within which P&O Nedlloyd (Rotterdam based) blocked this.

Container Terminal in return for giving NYK a minority stake in its ECT¹¹ terminal in Rotterdam. This new management can be considered the development phase of the indented berth, and it is still in progress.

Currently the terminal has a surface area of about 54 ha, designed to have a maximum capacity of 950,000 TEU¹²/year. It has 2 berths along the Amerikahaven of 635 metres of length, and a 400 metres-long indented berth, which enables post-Panamax vessels to be served by a maximum of 9 ship-to-shore cranes simultaneously. These cranes are among the biggest and the fastest container cranes at global level; each crane has an outreach of 61 metres, capable of serving 22 TEU wide container ships, and a lift capacity of 65 metric tons under the spreader and 100 metric tons under the cargo beam. The gantry frame of the crane leans back 6 m toward landside in order to clear the long boom from the other side of the slip. Since there are cranes operating on both sides of the ship, booms from opposite cranes may be within 10 m of each other. A double redundant safety system is provided in order to prevent boom-to-boom and spreader-to-spreader collisions.

The technical aspects above described could be successful elements in terms of Ceres terminal's competitive potential regarding terminal performance. Although not fully proven in practice (some trials were conducted) the Ceres Paragon Terminal had a very competitive status

¹¹ Europe Combined Terminals, part of the Hutchison Ports group.

¹² Twenty Foot Equivalent Unit: the basic unit of one box.

in productivity level compared to its main competitors: Rotterdam's Delta-terminal (operated by ECT) and Antwerp's North Sea-terminal (operated by Hesse Noord Natie at that time).

3.1.2 SI analysis

Phases

The case of the indented berth can now be analysed using the SI framework approach. First, three SI overviews of the case are presented concerning the initiation phase, the development phase, and the implementation phase. Next, the situation will be analysed in more detail, in line with the SI approach and framework.

The initiation phase can be evaluated as unsuccessful due to a negative combination between actors belonging to the maritime sector and infrastructure, institutional and interactions conditions, as can be observed in figure 1.

INSERT FIGURE 1 HERE

In the development phase, as can be seen in figure 2, the conditions are the same of the previous phase. The only difference is that the previously mentioned area has become an ellipse due to the involvement of new actors in the process of innovation who have negative interactions

with the institutional environment. This phase is currently in progress and might be successful if there will be a wider co-operation and risk-sharing among the majority of stakeholders involved at all levels. Until now, the support from global operators has been fundamental in promoting the Port of Rotterdam and consequently penalizing the competitive position of the Port of Amsterdam, which has become an overflow of Rotterdam.

INSERT FIGURE 2 HERE

The implementation phase may be considered as not yet started due to the recent development of the innovation, so the bullet areas in figure 3 indicate the required focus on indented berth for the future, involving many actors. It will be important to investigate the potential for the use of the innovation in other ports (maximising the weak interactions).

INSERT FIGURE 3 HERE

Infrastructure barriers / success conditions

There are specific infrastructure conditions which needed to be established in the case of this innovation. These conditions are related to the port of Amsterdam. In particular, in case of

increasing inbound and outbound flows of cargo, different kind of bottlenecks might be encountered with Amsterdam's lock complex (Kroon and Vis 2005): the vulnerability of the lock system including the risk of encountering damage upon entering the large North-lock that depends on a combination of wind force and direction, and unexpected jams in the lock complex, in particular jams in the North lock; the dimensions of the vessels calling the port of Amsterdam which can only accommodate ships exceeding Panamax dimensions at reduced draft; the lock process which could lead to difficult vessel planning and possible additional waiting times for liner shipping: liner vessels plan port calls as far as three months ahead, while bulk carriers usually make an unannounced call only 12 to 24 hours before arrival.

Institutional barriers / success conditions

Hard Rules. In this area of activity the key conditions for success of the indented berth need to be met. Currently there is a lack of European legislation and regulations concerning port terminals in general. That implies that the introduction of innovations like indented berths is not per se forced, and that it is not immediately promoted.

Soft Rules. In this area, the political, economic and entrepreneurial influences and values have shaped the context in which innovation has taken place, above all during the initiation phase. Despite the initial support from Amsterdam government and private parties, the innovative indented berth resulted as "not-yet successful" due to the presence of many barriers related to the

economic and political power of the leading parties in the massive container port of Rotterdam. Attempts by shipping line and terminal operator NYK, to draw attention to the Amsterdam-based terminal, were blocked by P&O Nedlloyd veto rights, in order to protect its interests in the port of Rotterdam (Kroon and Vis 2005).

Interaction barriers / success conditions

Weak Network Conditions. Although the strong link among the main stakeholders of this innovation, both public and private, one barrier in this field might be the inability to adapt to new technological developments at port level and the lack of a shared vision of future (particularly technological) developments. Indeed, the revolutionary concept of two-sided handling of containers in a dock may represent advantages only for the single ship served, while impacting on the whole port cycle including also the management of the gates and yards, and planning for accomodating other ships. Hence, this innovation can be evaluated as a success only when referring to the ship-berth operations and it becomes not-yet successful when considering the efficiency of the terminal as a whole. This could be an explanation of why this type of berth is still the only one built in the world.

Strong Network Conditions (acting in a negative sense). It may be argued that the strong connection among the lobbyist industry groups in the port of Rotterdam led to the actual unsuccessful condition of the indented berth.

Capabilities barriers / success factors

There appeared to be no lack of capabilities on the part of any of the actors, except for Ceres not being able to attract the cargo it once promised to attract.

3.1.3 SI and Overall Case Conclusions

The SI analysis has shown that the indented berth innovation has not utilised the correct approach to establishing success conditions until now, due to the presence of several barriers.

For an organizational innovation to be successful there is a need during the initiation phase for a strong commitment of resources, time, and belief in the innovation by the supporting private firms (in this case global terminal operator) together with public stakeholders. The analysis of this innovation shows that economic and political barriers (such as high competition with the port of Rotterdam and influence of its lobbyist groups) can make “unsuccessful” the innovation despite its new technologies.

Moreover, a successful future development of the Ceres Paragon Terminal with more competitive power on the long term may not be excluded, even if some barriers have to be

overcome in the next years, starting from the economic and infrastructural ones. There are also technical elements to change as they could have made the indented berth “not-yet successful”, such as lower driving distances around indented docks, difficulties at time of starting and time of finishing with quay cranes (as it is not possible to use cranes for other vessels till the last one finished the bay), difficult bunker operations of the vessel, expensive quay walls, and safety-wise. Or maybe this revolutionary concept of indented berth might be successful if applied in another port, although global terminal operators are quite sceptical about this due to the current failure in Amsterdam.

3.2 Case 2: Integrated Port Community System

3.2.1 Background

The development and implementation of value-added information systems, known as port community systems (PCS), is another example of a technological innovation, with secondary managerial, organisational and cultural aspects. It increases port productivity and upgrades the services offered by the various actors and operators. Apart from the actual exchange of information, as well as the electronic transactions provided, PCS contribute to port efficiency security and cost control in the context of an evolving international market.

Clearly, the development, implementation and operation of a PCS can be regarded as a “product”, “service” and “process” innovation since it improves measurably the multimodal operations of a port. Findings in literature demonstrate that the application of information exchange systems, apart from leading to efficient, safe and customer-oriented transport services, aid in the development of more efficient intermodal operations. The application of these systems fosters interoperability and interconnection of port services and enhances competitiveness of economic transactions.

The present case deals with the development, implementation and operation of the PCS of Thessaloniki. In order to position this port as an important trade center in South East Europe, as well as an intermodal gateway, Thessaloniki Port Authority took advantage of the developments in the area of ICT and took strong initiatives towards process modernization. In accordance to this, it was decided to implement an integrated system of Advanced Information Technology Applications at the container terminal with the aim of providing the port with an important asset that would allow its entry to leading groups in the Mediterranean Basin.

Technologically, the Intermodal Freight Terminal System (FRETIS_IFT), in other words the PCS of Thessaloniki, was developed by a local R&D company. The system was composed of various modules and subsystems that facilitated the exchange and management of information between all the actors involved around container logistics.

3.2.2 SI analysis

Many key actors were involved in the development and implementation of the PCS of Thessaloniki. Thessaloniki Port Authority decided to provide the port with an important asset against its competitors. The R&D company was the one who actually built the system on behalf of the port, customized to its needs and specific commodities. The actual users of the system, port clients (e.g. shipping agents and truck operators) and the port's workforce were the final evaluators.

There are three types of factors affecting the implementation of this innovation: technological, organizational and environmental. An important dimension of the technological perspective is the anticipated benefit of the innovation for the organisation. The greater the benefit expected, the larger the likelihood of the port to adopt the innovation. The organisational culture of a Port Authority as well as the ability of the employees to adapt in changing working environments influences the organisational adoption of the PCS. Finally, the technology used by competitors has urged the port to push forward and incorporate innovative technological systems in order to gain a marginal advantage.

Phases

In the initiation first phase of the innovation process, there are two main actors. The principal actor is Thessaloniki Port Authority which decided to implement the system. The second actor is the R&D company, which undertook the development and the installation of the system. Their relations and interactions are presented in figure 4.

INSERT FIGURE 4 HERE

The development phase relations are described in figure 5. Negative combinations clearly are the lack of infrastructure and network involvement of other chain actors, except the initiators.

INSERT FIGURE 5 HERE

After its development, the system was tested for a year in a pilot stage. The relations during this intermediate phase are presented in figure 6. In this phase, negative network combinations were turned into positive ones.

INSERT FIGURE 6 HERE

After the pilot phase of the system, the most important issue characterizing the implementation phase was the approval of the PCS from all the actors involved and the encounter of all the reactions generated. Specifically, all the involved actors acquired the new IT technologies offered by the PCS (see figure 7).

Infrastructure barriers / success conditions

The lack of appropriate technologies (information and communication software and hardware) as well as the lack of interoperability inside the terminal can be identified here as barriers. During the development phase, neither the users nor the port itself possessed the necessary infrastructure to apply a PCS (see figure 5).

Thessaloniki Port Authority with the implementation of the system obtained the IT infrastructure. The implementation permitted communication among all actors involved. It is noted that port users were not expected to invest in new IT infrastructure for the implementation of the system.

Institutional barriers / success conditions

The key problem in the innovation process was concentrated on soft (cultural) issues. In Thessaloniki Port, employees felt that their work positions and power were threatened (see figure 6). Thessaloniki Port Authority managers however had the formal power to impose the needed changes to the employees and to overcome the initial conflicts. Furthermore, the system was included in the strategic plans of both the port and the R&D company and therefore became a priority.

It is noted that in the implementation phase, the PCS did include special modules for the customs office, as the cultural issues continued to persist.

Interaction barriers / success conditions

The case is dominated by the favourable and unfavourable impact of strong interactions. Positive was the impact of the strong network relation between the Thessaloniki Port Authority and the R&D company developed over a number of research projects. The R&D company was well networked with the international market and was up to date on innovations on information exchange software and systems. They were also well informed on the EU FPs available in order to ensure the necessary funding for the project. Positive also was the stimulus of competition. The deployment of a PCS enabled the port to match any of its competitor ports.

A negative factor was the impact of the strong Unions in the port area. The PCS introduced great changes in procedures followed by equipment (cranes, straddle carriers) operators. The lack of familiarity of older employees with the new IT technologies increased their resistance (capacity issue). Union leaders were the first to turn negative towards change and influenced, as expected, the rest of their co-workers.

Capabilities barriers / success factors

The container terminal of Thessaloniki lacked the necessary know-how for the development of the PCS. In addition, the workforce of the terminal was not familiar with information technologies. This lack of capabilities was supported by the R&D Company, which possessed the knowledge capital to implement the PCS. Furthermore the know-how obtained from this project could turn into a marketing asset for further exploitation. An important aspect in overcoming users' resistance was the development of their capacity in informatics (see figure 7). This permitted the materialization of processes in a fast, paperless and errorless manner.

The cooperation between the R&D Company and Thessaloniki Port Authority allowed the development of the innovation. These actors have combined their networks and their experience to promote the new concept. The more important challenge, however, was to introduce cultural change to the employees and the terminal clients. Firstly, Thessaloniki Port Authority management, determined to introduce the innovation, was able to overcome the reactions and the

impediments posed by the employees. Secondly, the R&D company possessed the necessary know-how to design the system in a way that imprinted the actual processes of the port. This led to small modifications to the procedures and simplified the final adoption of the system. Thirdly, the majority of the clients embraced the system since it became a useful tool for the promotion of their interests.

However, emphasized here is that leadership embodies the element with the greatest impact on success as employees initially reacted negatively and resisted change. Their power inside the port was under question, their work procedures were modified and they were afraid that their work positions were threatened. Their reactions decreased the likelihood of success and delayed the adoption of the system. Their overall stance was negative. Nevertheless, despite the adversities, the rigid strategic plan of the port, combined with the powerful and respected leadership, proved to be sufficient to overcome the hurdles.

3.3.3 SI and Overall Case Conclusions

In conclusion, the survival and development of the terminal in a volatile and competitive environment was the ultimate and most pressing goal that imposed port management to focus on the computerization of the terminal. The new PCS had a definitely positive impact on the efficiency and the productivity of the port business and customer satisfaction.

3.3 Case 3: Cold Ironing in European Ports

3.3.1 Background

Cold ironing, also known as Shore Connection, On Shore Power Supply, Alternative Maritime Power Supply, is a process enabling a ship to turn off its engines while berthed and plug in to an onshore power source, and is a pure technological innovation case. The ship's power load is transferred to the shore-side power supply without disruption to onboard services. This process allows emergency equipment, refrigeration, cooling, heating, lighting, and other equipment to receive continuous electrical power while the ship loads or unloads its cargo.

From a technical and operational viewpoint, cold ironing is a complex technological system made by the following elements. Electrical infrastructure at ports (engineered and integrated systems are required to fit all types of ports); electrical infrastructure on ships (retrofits or new builds); connection and control solutions to ensure personnel safety and seamless power transfer. In particular, a complete onboard system solution should include all power equipment necessary to connect the ship to a shore-side power point; all control equipment necessary to secure seamless automated power transfer of the ship load from the onboard power plant to the shore-side source and back. Furthermore, this integrated system needs to comply to new international standards (including High Voltage Shore Connection (HVSC) by IEC, ISO and IEEE, IEC 60092-510 edition1 IEC/ISO PAS).

Auxiliary engines run by ships in port generate SO_x, NO_x, CO₂ and particle discharge as well as noise and vibration. These pollutants cause negative health and environmental impact on the surrounding communities. Independent studies have found that cold ironing generates many environmental and social benefits, by reducing emissions from vessels docked in port, so it can be considered a relevant part of “green ports” concept¹³.

Historically, ships were not subject to emissions controls and regulation, and diesel engines were their main source of power. However, several studies demonstrated that, of total global emissions, ships produce 2% of CO₂, 10-15% of nitrogen oxides (NO_x) and 6% of sulphur oxides (SO_x) (ABB Marine 2010). As a consequence, new environmental regulations have been mandated by the International Maritime Organization (IMO) at global level. In 2004, MARPOL (73/78) Annex VI has placed limits on sulphur oxide (requiring use of <4.5% sulphur fuel by 2010, and its target is to reduce world maritime sulphur output to <0.5% by 2020) and nitrogen oxide emissions from ship exhaust and prohibited deliberate emissions of ozone-depleting substances. In 2005, EU Directive 2005/33/EC has limited the amount of sulphur to 0.1% in all marine fuel used while at berth for more than 2 hours in European ports, since 2010. In 2006, a new environmental EU recommendation came into force: it is the EU Recommendation 2006/339/EG, destined to member countries to promote shore-side electricity facilities. The EC recommendation also called for the development of harmonized international standards and provided guidance on costs and benefits of connecting ships to the electricity grid.

¹³ ‘Green ports’ stand for concepts which aim at making ports more environmentally friendly.

The system has been introduced successfully in several US and Swedish ports, including Gothenburg. A supporting factor which plays a role is the initiative of a number of the largest ports in the world, led by Port of Rotterdam, to grant ships with cleaner engines a reduction of harbor dues (Green Award). In this way, the responsibility for emission reduction lies with the shipping companies, which makes it attractive to them.

3.3.2 SI Analysis

Phases

The initiation phase can be evaluated as unsuccessful due to a negative combination between actors belonging to maritime sector and infrastructure and institutional conditions, mainly due to the lack of interoperability and standardisation above cold ironing in Europe (see figure 8).

INSERT FIGURE 8 HERE

The development phase is currently in progress; it presents the same conditions of the previous phase (see figure 9). The only difference is the previous area that has become an ellipse due to the involvement of new actors in the process of innovation who show negative interactions with the institutional environment. The development phase might be successful if there will be a wider cooperation among the various actors involved.

INSERT FIGURE 9 HERE

The implementation phase has not been reached due to the recent development of the innovation, so the areas in figure 10 indicate the required focus on cold ironing for the future, involving many actors.

INSERT FIGURE 10 HERE

Infrastructure barriers / success conditions

There are specific infrastructure conditions which needed to be established in the case of this innovation. Cold ironing needs a dedicated infrastructure at marine terminals. They require extra electrical capacity, conduits, and the “plug” infrastructure that will accept power cables from a vessel. A large container ship usually requires approximately 1,600 kilowatts (kW) of power while at berth, but the power requirements can differ substantially, depending on the size of the vessel and the number of refrigerated containers on board (Sisson and Mc Bride 2010). Port electrical infrastructure equipped for cold ironing costs more than a conventional terminal, and it represents an investment that not all ports have at their disposal or are able to do. A possible

solution to incentivize ports to invest in this new technology could be the use of emission reduction credits: they could help offset this expense and provide short term incentives.

Institutional barriers / success conditions

Hard Rules. In this area of activity the key conditions for success of the cold ironing and “green ports” need to be met. Currently there is a lack of European legislation and regulations concerning cold ironing in comparison to the USA: the spread of cold ironing at the ports of Los Angeles and Long Beach is a consequence of a stricter legislation including the MEPC 59/6/5, a joint proposal from USA and Canada to IMO to designate an Emission Control Area (ECA) for specific portions of U.S. and Canadian coastal waters. Another barrier in this field is represented by some technical problems concerning lack of standardisation. This relates to compatibility of electricity parameters: ships, built in different international yards, have no uniform voltage and frequency requirement. Some ships use 220 volts at 50 Hz, some at 60 Hz, others use 110 volts. Primary distribution voltage can vary from 440 volts to 11 kilovolts. Load requirement varies from ship to ship – ranges from a few hundred kW in case of car carriers to a dozen or more MW in case of passenger ships or reefer ships. Connectors and cables are not internationally standardised, though work has progressed in this direction.

Soft Rules. In this area, the economic and entrepreneurial influences and values have shaped the context in which innovation has taken place, above all during the initiation phase. First, the

cost of electric energy represents a first barrier to the spread of cold ironing in Europe. However, cold ironing could represent a cheaper solution in certain cases if compared with vessels switching to marine distillate (MDO) while in port as required by many local regulations (MDO burns cleaner than bunker fuel, but it is about twice as expensive). Second, there are no incentives, motivation, spirit of entrepreneurship coming from shipping companies and other interest groups to promote this innovation. This is probably due to their interest in adopting alternative solutions such as innovative engines and innovative fuelling systems (e.g. the LNG propelled ships).

Interaction barriers / success conditions

Weak Network Conditions. A possible barrier in this field might be the inability to adapt to new technological developments at ship and port level and no shared vision of future (technological and social) developments. Indeed, the main benefits generated by the application of cold ironing are social and environmental. Firstly, if this innovative technology is implemented properly, it may contribute to air quality improvement, by reducing CO₂ emissions, most notably in Japan, UK, and Italy (Hall 2010). Indeed cold ironing system, due to the higher efficiency and to the “limiting emissions facilities” in power plants, allows reducing more than 30% of CO₂ emissions and more than 95% of nitrogen oxygen and particulate. It has been demonstrated that, in 10 hours of stop of a cruise ship, its emissions drop from 72.2 to 50.1 tonnes of CO₂, from 1.47 to 0.04 tonnes of nitrogen oxide, and from 1.23 to 0.04 tonnes of sulphur oxide. This system also allows to reduce noise pollution. Other positive impacts are

better onboard comfort while in port, green profiling for ship owners and customers, and also reduced lifecycle cost by reduced fuel consumption and maintenance cost.

Strong Network Conditions. It can be argued that there is a strong connection among the lobbyist industry groups interested in promoting other environmental policies in European ports which led to unsuccessful condition of cold ironing as a positive indicator of “green ports”.

Capabilities barriers / success factors

There appeared to be no lack of capabilities on the part of any of the actors.

3.3.3 SI and Overall Case Conclusions

The SI analysis has shown that cold ironing innovation has not used the correct approach to establishing success conditions until now, due to the presence of several barriers. The analysis of this innovation reveals that economic, legal and technical barriers (such as high cost of energy, high infrastructure costs, lack of standardisation for the equipment, and the lack of European legislation) can make “unsuccessful” the innovation despite its environment-friendly technology.

A successful future development of cold ironing in Europe may not be excluded, taking into account its success in Alaska and California, where the main ports have been obliged to adopt it in order to reduce air and noise emissions at ports. Another relevant factor contributing to the development of cold ironing is the cost of electricity that in Europe is higher than in Alaska and California. Also the cost of port infrastructure represents a strong barrier for European ports. Finally, the actual level of pollution in Europe should stimulate the spread of “green ports” and cold ironing to achieve their environmental benefits. Otherwise, air pollutants emitted from ships in the EU will exceed all combined land-based sources by 2020.

4. Findings from the analysis: typologies of innovations, actions and factors, and recommended actions

It is important to recognise that a number of typologies or classification systems are possible to cover the selected innovations. The varied and eclectic nature of the innovations means that a number of descriptors may be used, singly or in combination to classify innovations. For instance an innovation may be regarded a hybrid including technology and organisational change or organisational and cultural change. However, in this section, we will focus on the initial, narrower typology/classification (based on the predominant component of the innovation; though as indicated earlier the predominant component may well vary dependent on the temporal phase reached in the innovation process).

The typology of actions/interventions is based on the SI framework and includes three broad groups of factors: key groups of actors (including their capabilities), key institutional factors, and key socio-economic environment factors (involving interaction). Obviously for any innovation, the weighting of the actions required for success will include a ‘weighted’ mixture of these three groups of factors. It is also the case, however, that there is one factor which is common to all successful materialization of innovations: having a positive overall socio-economic environment. The existence of sufficient economic demand is a key pre-requisite for commercial innovation success.

Determining whether a positive socio-economic environment exists, and in particular whether sufficient economic demand is present, is an important investigative element in the policy analysis of innovation and is also a pre-requisite for successful innovation from the viewpoint of the initiator and developer of any commercial innovation. Again, the temporal aspect of the innovation process comes into play. Timing well the introduction phase, or particularly the development phase, of an innovation process affords a mechanism for achieving the presence of an optimum or near-optimum socio-economic environment. The analysis developed, partly reported above with regard to the three innovations cases considered, and augmented with a more general analysis of the wider set of the other 20 transport cases, highlighted some specific success conditions concerning the actors involved and the institutional and socio-economic factors as well. They are briefly reported in the following table.

Table 1 – Key network of actors, institutional and socio-economic factors for successful innovations

Key networks of actors	<p>The involvement of knowledge institutes to assist with developing the innovation and its ancillary aspects, e.g. standards.</p> <p>Ensuring that key actors have the requisite capabilities to perform the functions required.</p> <p>Utilising strong networks, for instance across sectors and intermodally, to enable innovations to develop effectively.</p> <p>Avoiding an innovation to be ‘captured’ by strong networks (evt. competing concepts) and ensuring that soft network links are established.</p>
Key institutional factors	<p>Ensuring that hard rules (laws, taxes, and regulations) are recognised in terms of the impact they may have on the innovation, also by public bodies</p> <p>Ensuring the adequacy of the infrastructure required to implement the innovation.</p>
Key socio-economic factors	<p>Paying sufficient attention to the ‘soft rules’ that apply in the sectors or countries involved in the implementation of the innovation, including the presence or anticipation of sufficient socio-economic demand and the nature of potential competition from other actors, other sectors, or other potential innovations.</p> <p>Accessing available public funds (grants and loans) which can subsidise innovation costs in the initiation and development stages.</p>

The port sector appears to be rather conservative in introducing innovation in its processes. Maybe this is a consequence of a network of players deeply interrelated either horizontally and vertically, with a great use of standards, that slows down the adoption of innovations.

Each of the three analyzed application cases was characterized by the pros and cons for innovation process. These variables were composed by several sub-categories involved in maritime markets. The evaluation covered also the initiation, development and implementation phases for each innovation, and in that way unravels the innovation process.

Concerning the key factors, the technological aspects resulted among the most important followed by the political and process-related ones. The technology marks the starting point for initiatives but the political support becomes crucial when new technologies are ready to be implemented. In other words, the strategic role played by some actors at port politics' level has enough drive for fostering innovation. This is the case of the Dutch indented berth equipped with innovative technical and organizational systems. However, the political pressure for promoting the Port of Rotterdam resulted in a penalisation for the new terminal in the Port of Amsterdam. Notwithstanding its revolutionary technology, this innovative berth has become squeezed between opposing interests by its shareholders and stakeholders.

Surprisingly, the role of incentives was evaluated during our three-case analysis as not so relevant as an economic factor for innovation in the port industry. This could be a consequence of

the oligopolistic form of the market due to the presence of few big players investing privately in new technologies, and only in few cases supported by public funds, such as in the infrastructure of the indented berth.

Moreover, the most important economic factors in the maritime sector appear to be providing net benefits for all the actors involved in the transport chain or even for the whole industry. This means that net benefits related to all players can be more important in determining the success of an innovation than revenues for a single, private operator.

With regard to the barriers, again the technical aspects result as the most relevant in sea-port related cases. The case of cold ironing demonstrates this best as it is characterised by a lack of standardisation. This concerns compatibility of electricity parameters: ships, built in different international yards, have no uniform voltage and frequency requirements.

Given the difficulty of measuring innovation, there is not a clear criterion for evaluating the success of the innovation process. The temporary failure or "not-yet success" may derive from the combination of various categories of key factors, mainly political and socio-cultural, influencing all the stages of development.

The presence of several different barriers may limit the spread of innovative cases and determine the failure of one initiative in one or more phases of its cycle. In particular, in many cases the main barriers are represented by technical elements and high costs. However, barriers

are not an obstacle for the development of an innovation, and once they are overcome, they allow the innovation to be successful in the following phases. As shown through SI analysis, for a commercial innovation to be successful there is a need during the initiation phase for a strong commitment of resources, time, and belief in the innovation by the supporting private multinational firms (e.g. global container operators in the maritime sector) plus a degree of public subsidy from government to the company(ies) involved; the analysis of a recent innovation such as the indented berth reveals the lack of involvement and funds of public institutions, and the presence of several technical barriers, mainly related to infrastructure conditions.

5. Conclusions and recommendations

The added value of this paper has been to provide a codified set of recommended actions/interventions both for commercial participants and for public policy-makers in the surface transport sector(s). Some recommendations are summarized below.

In relation to those innovations which may be classified as principally technology-based innovations (as cold ironing and integrated port community system), it may be observed that the emphasis is likely to be on public policy actions/interventions being most effective in terms of support for the initiating of the innovations. For the commercial sector it is important that access to such sources of funds and of knowledge in the initiation phase of innovations is sought, as a key element in moving forward from the original conception. Subsequent action during the

development phase of the innovation process will require the establishment of hard rules, e.g. standards, may also be required. During the implementation phase, public investment in infrastructure and/or hard rules may again be required, and it will be important to ensure that all actors have the requisite technological (and organisational) capabilities.

In relation to those innovations which may be classified as clearly having also organisation/management aspects (e.g. indented berth and PCS), it is observed that they may be supported positively by actions/interventions which ensure that all the relevant network actors (including weak actors) are involved in all of the phases of the innovation process, and that the business and/or socio-economic benefits are clearly attributable to each of the actors. The adequacy of infrastructure may be a constraining factor to be overcome in some instances and the need for standards may be crucial to the success of an innovation. Finally, it will be necessary for the initiator/promoter to market the innovation during the implementation phase. Obviously, it cannot be claimed that the interventions suggested, based on this innovation approach, will be successful. However, it can be seen that the areas suggested for public intervention are related, not to areas which may be said to be the province of the private, commercial sectors (suppliers and customers), but to those areas where new or modified rules may be introduced to facilitate or motivate the innovations. These rules ('hard rules' mainly, in the SI terminology) may include laws, regulations (including standards), taxes, grants, loans.

The types of interventions indicated in the recommendations summarized in this paper should be of use in supporting and accelerating the spread of commercial innovations within the

sea-port sector, but more generically also in other transport sector, provided that the same typology applies. This emphasis should not be interpreted as under-playing the importance of the approaches suggested by the analysis in relation to the innovation strategies adopted by commercial actors. It is clearly the case that the major impetus for innovation is going to rest with the commercial sectors. There are lessons to be learned by the commercial sector; the role of public policy interventions is to provide support, where necessary, to ensure that the commercial strategies are effective in delivering and spreading the innovation across the various transport sectors, and that lock-in and monopoly strategies of private innovative actors are avoided.

One advantage of the codified approach to the policy intervention recommendations indicated above, is that it could be developed into a decision-tree/algorithmic approach to decisions on how best to support the innovation process in particular circumstances (i.e. taking account also of the socio-economic environment, the type of innovation, and the surface transport sector(s) involved). There is therefore room for further research building on this paper, widening the scope in number and types of cases.

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Figure 1: Overview of indented berth case: initiation phase

Actors				
	Maritime Sector: Ports and Terminal Operators	Shipping Companies / Container Operators	Third parties Lobbyists; Consultants; Shipbuilders	Knowledge Institutes EU RTD Funding, Standards Bodies
Institutional Environment				
Infrastructure conditions <i>Roads, Ports, Ships</i>				
Institutional conditions Hard Rules: <i>Laws, regulations</i> Soft Rules: <i>social and economic values,</i>				
Interaction conditions <i>Weak network problems</i>				
<i>Strong network problems</i>				
Capabilities				

White bullets mark the actions which actually were taken in the process of innovation, but with negative combinations.

Figure 2: overview of indented berth case: development phase

Actors	Maritime Sector: Ports and Terminal Operators	Shipping Companies / Container Operators	Third parties; Lobbyists; Consultants; Shipbuilders	Knowledge Institutes; EU RTD Funding; Standards Bodies
Institutional Environment				
Infrastructure conditions <i>Roads, Ports, Ships</i>				
Institutional conditions Hard Rules: <i>Laws, regulations</i> Soft Rules: <i>social and economic values,</i>				
Interaction conditions <i>Weak network issues</i>				
<i>Strong network issues</i>				
Capabilities				

Figure 3: overview of indented berth case: implementation phase


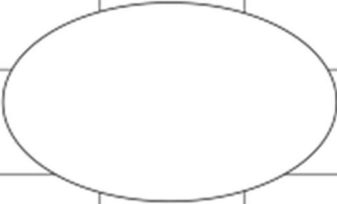




<div> <div>Actors</div> <div>Institutional Environment</div> </div>	Maritime Sector: Ports and Terminal Operators	Shipping Companies / Container Operators	Third parties; Lobbyists; Consultants; Shipbuilders	Knowledge Institutes; EU RTD Funding; Standards Bodies
Infrastructure conditions <i>Roads, Ports, Ships</i>				
Institutional conditions Hard Rules: <i>Laws, regulations</i> Soft Rules: <i>social and economic values,</i>				
				
Interaction conditions <i>Weak network issues</i> <i>Strong network issues</i>				
Capabilities				

Figure 4: overview of PCS case: initiation phase

	Thessaloniki Port Authority	System Developer (TREDIT)	Shipping Agencies	Port Workforce	Truck Operators	Custom Agents
Infrastructure						
Hard Institutions						
Soft Institutions						
Networks						
Capacities						
Market Demand						

White bullets mark the actions which actually were taken in the process of innovation, but with negative combinations. Blue ones mark the actions with positive combinations.

Figure 5: overview of PCS case: development phase



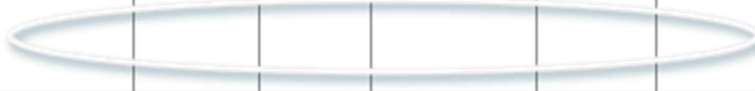

	Thessaloniki Port Authority	System Developer (TREDIT)	Shipping Agencies	Port Workforce	Truck Operators	Custom Agents
Infrastructure						
Hard Institutions						
Soft Institutions						
Networks						
Capacities						
Market Demand						

Figure 6: overview of PCS case: pilot phase

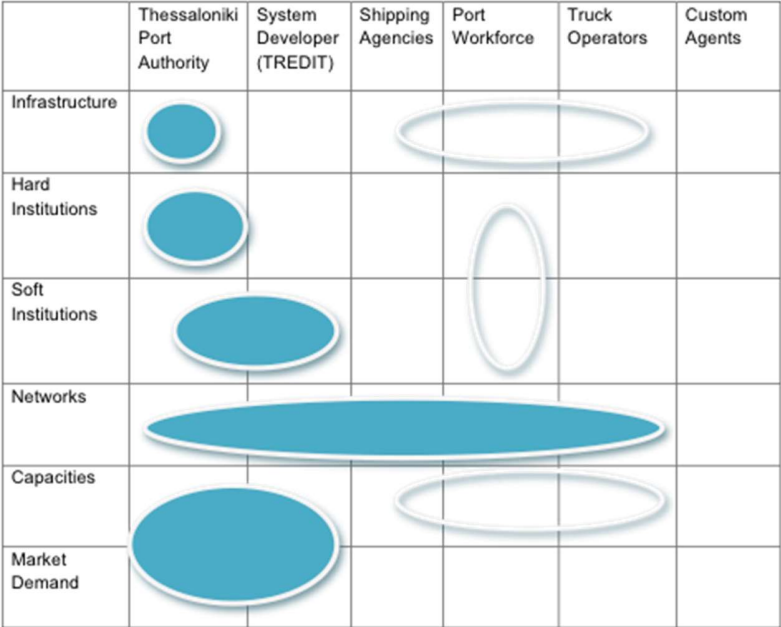


Figure 7: overview of PCS case: implementation phase

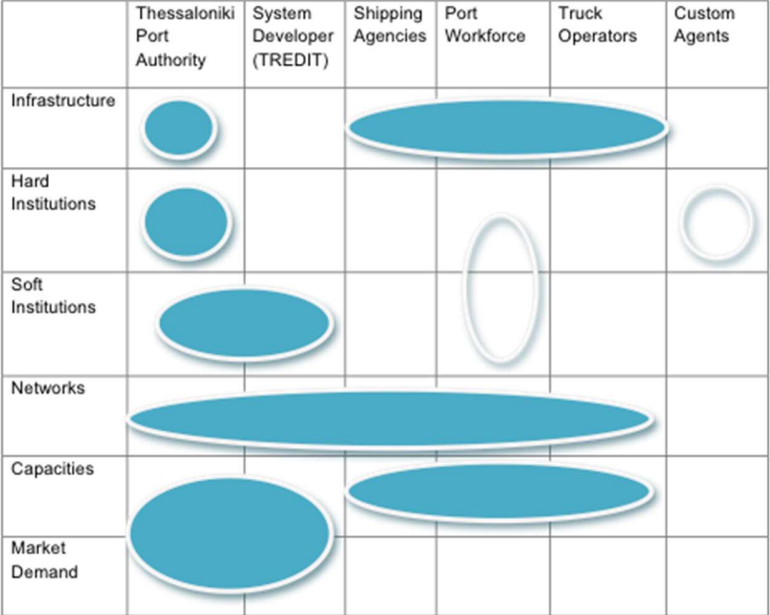


Figure 8: overview of cold ironing case: initiation phase


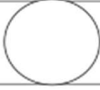
	Actors				
		Maritime Sector: Ports and Terminal Operators	Shipping Companies	Third parties Lobbyists; Consultants; Shipbuilders	Knowledge Institutes EU RTD Funding, Standards Bodies
Institutional Environment					
Infrastructure conditions <i>Roads, Ports, Ships</i>					
Institutional conditions Hard Rules: <i>Laws, regulations</i> Soft Rules: <i>social and economic values,</i>					
Interaction conditions <i>Weak network problems</i> <i>Strong network problems</i>					
Capabilities					

Figure 9: overview of cold ironing case: development phase



Actors	Maritime Sector: Ports and Terminal Operators	Shipping Companies	Third parties; Lobbyists; Consultants; Shipbuilders	Knowledge Institutes; EU RTD Funding; Standards Bodies
	Institutional Environment			
Infrastructure conditions <i>Roads, Ports, Ships</i>				
Institutional conditions Hard Rules: <i>Laws, regulations</i> Soft Rules: <i>social and economic values,</i>				
Interaction conditions <i>Weak network issues</i> <i>Strong network issues</i>				
Capabilities				

Figure 10: overview of cold ironing case: implementation phase

<div>Actors</div> <div>Institutional Environment</div>	Maritime Sector: Ports and Terminal Operators	Shipping Companies	Third parties; Lobbyists; Consultants; Shipbuilders	Knowledge Institutes; EU RTD Funding; Standards Bodies
Infrastructure conditions <i>Roads, Ports, Ships</i>				
Institutional conditions Hard Rules: <i>Laws, regulations</i> Soft Rules: <i>social and economic values,</i>				
Interaction conditions <i>Weak network issues</i> <i>Strong network issues</i>				
Capabilities				