A FRAMEWORK FOR SUCCESSFUL IMPLEMENTATION OF GREEN INNOVATION IN SEAPORTS

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ABSTRACT

Environmental sustainability in the port industry is of growing concern for port authorities, policy makers, port users and local communities. The present paper analyzes a number of port innovations. Innovation can provide a solution to some of the main environmental issues faced by ports, but is often met with resistance as a result of the associated large capital investments or the risks of being locked-in in unsuccessful technologies. While certain types of technological or organisation innovation can be satisfactorily analysed using closed system theories, in the case of seaports and in particular in the area of environmental sustainability, more advanced conceptual frameworks have to be considered. These frameworks need to be able to account for the multiple stakeholder nature of the port industry and of the network and vertical interactions that environmental sustainability calls for. The main objective of this analysis is to investigate the success factors of adopting port innovation initiatives. This paper in particular elaborates a framework for the successful implementation of innovation in seaports in the area of environmental sustainability. This proposed framework, building in part on research concepts developed in the InnoSuTra FP7 project, makes use of a more

quantified approach of linking actions to port authority green objectives and finding out how successful certain green innovation initiatives are in achieving objectives. Several case studies are used to test the framework against real innovation examples, such as onshore power supply, or alternative fuels. In the paper, it is argued that only those innovations that fit dynamically port actors' demands and the port institutional environment stand a chance to succeed.

Keywords: Sustainability, Green ports, Innovation, Systems' Innovation.

1. INTRODUCTION

The relation between transport and society is complex. Traditionally, transport is seen as a derived demand, i.e. economic activity determines the demand for transport (see e.g. Markianidou et al., 2011). However, firms that provide transport and logistical services contribute to the economy too. They do so in a positive way, by generating jobs and tax income and by doing investments (Blauwens et al., 2010). In many economic activity sectors, the management and organisation of the logistics chain is a major part of the overall strategy, including the location of production in regions all over the world and connecting all these places. Transport therefore has a certain influence and decision power in production chains.

However, transport unfortunately also generates a number of negative impacts for which it does not compensate, so-called negative externalities. These include infrastructure damage, congestion, accidents, pollution and noise generation. Therefore, the transport sector is also put under pressure by a wide group of stakeholders, going from customers, over governments and unions up to environmentalist groups (Sys, et al., 2012). Internalising external costs for instance is meant to improve the eco-awareness of the sector, and should increase the efficiency and result in a fair competition between the transport modes.

In the port industry, environmental sustainability is of growing concern for port authorities, policy makers, port users and local communities. Many ports appear (or are planning) to be green, but how much green are they really? And how is sustainability really affecting the day-to-day ports' operating rules? The term green implies a low environmental impact, then it means a relative measure: the result of a comparison among different ports or among the same port in different moments. Moreover, the term green implies that externalities are taken into account. Therefore, the approach to this topic must be economic and, concerning the port industry, the right level of analysis is that of the Port Authority (from now on, PA), i.e. the entity in charge of maximising the economic spillovers of port activities, at least where the landlord model is applied.

Also private firms and organizations may pursue environmental goals or they can revise their production processes in order to reduce their carbon footprint, but in most cases it is either the willingness to comply with a compulsory rule or an internal decision in order to cultivate their

image or even for marketing reasons (Sharma et al., 2010). Greening the firm profile is often a nice additional benefit to efficiency pursuit or compliance need, and also in the maritime industry costs or regulation might be the main driver behind certain strategies. Efficiency, regulatory compliance and environmental sustainability, however, can at times lead to diverging priorities.

The fragile balance among these objectives can only be established and maintained by going radically for innovations and innovative processes. Innovation is crucial for the materialization of sustainable transport (Van Wee, 2003). Some of the technical innovations require however a rather long time horizon, while some process innovations can often be implemented much faster. Although innovation is one of the key success factors of private businesses, the complex network nature of transport and logistics where freight and passengers interact, may require some intervention of the government in the innovation process in the transport and logistics sector. Furthermore, private investments in innovations are quite risky because of market imperfections and the interdependency of the different players in the transport and logistics sector.

Innovation can provide a solution to some of the main environmental issues faced by ports (Yap and Lam, 2013), but also in this sector it is often met with resistance as a result of the associated large capital investments or the risks of being locked-in in unsuccessful technologies. Ports have been also the ground for the proposal of new technical innovation, and, often as a response to upcoming regulation, ports are often faced with complex decisions aiming at selecting new approaches. In many cases, such decisions are characterised by large capital commitments and substantial lock-in effects.

Furthermore, innovation in general seems to happen very rapidly these days. It therefore very strongly steers the pace and the way with which economic sectors are developing, and manage to remain competitive. 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 the International Transport Forum (2012) has shown the transport sector to score less than the average for the economy as a whole when it comes to innovation. At the same time, it can be concluded from existing literature and 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 never have generic conclusions been drawn with respect to factors, which benefit or disbenefit the successful adoption of innovative ideas in transport, and the role that transport actor strategies play into that.

Innovation in surface transportation and in logistics chains, as a change producing mechanism, needs to be much further assessed and benchmarked, so as to assess which

innovations will generate which chain impacts, which conditions will conduce actors to innovate, or prevent them from doing so, and finally also what governments can do to stimulate innovation. While most types of technological or organisation innovation in transport can be satisfactorily analysed using closed system theories, in the case of seaports and in particular in the area of environmental sustainability, more advanced conceptual frameworks have to be considered. These frameworks need to be able to account for the multiple stakeholder nature of the port industry and of the network and vertical interactions that environmental sustainability calls for.

This paper aims at investigating successful innovations improving environmental sustainability of seaports. This proposed framework makes use of a ranking system to assess the success of innovation types in relation to a set of predefined green objectives. Several case studies are used to test the framework against real innovation examples, such as onshore power supply, or alternative fuels. In the paper we will argue that only those innovations that fit dynamically port actors' demands and the port institutional environment stand a chance to succeed. Those innovations that are not aligned with the overall port strategy, might be successful, but do not contribute to a coherent green policy for the port. The paper also has a value as it addresses the issue of green objective definition and proposes a list of green objectives for ports based on the general strategic objectives of a port authority.

The paper is structured in the following way. The next session describes the methodology used to survey the innovation forms and rank them with respect to the green objectives. It also explains how the green objectives have been obtained and verified. Section 3 presents the selected green objectives and provide an explanation of what is meant by each of them. Section 4 presents the results of the ranking exercises and provides some interpretation of the results. Section 5 concludes.

2. METHODOLOGICAL APPROACH

The paper aimed at ranking innovations in terms of success with the objective of learning lessons on how successful innovation can be achieved in the area of sustainability. It was the objective of the authors to have a sample of ports from a variety of regions. The selected ports may be considered a convenience small based on the authors' ability to obtain access and register port experts' insights and assessments. Regardless, the selected ports represent significant diversity in terms of size, locality, competitiveness, cargo handling characteristics and market positioning rendering the sample valid for analysis.

The ports selected are: Antwerp, Genoa, Hamburg, Los Angeles/Long Beach, Rijeka, Singapore and Zeebrugge. For each port the team attempted at selecting one or two environmental policy actions and within each of such actions an innovation that could be ranked in term of success.

A clear definition of *success* in the area of green innovation in ports is not available. It can be argued that success is in relation to the strategic objectives of the port authority (PA). The authors decided to approach this problem by defining and agreeing a set of common, well accepted strategic objectives linked to the standard functions of a PA, such as landlord, regulator, operator, community manager as discussed in Verhoeven (2010), Meersman, et al. (2005), Meersman and van de Voorde (2010). These strategic objectives have been revisited in a 'green' perspective. A green strategy in fact cannot, and should not, be discussed independently from the overall port strategy, at least in general terms. A list of green objectives has then been validated using the expertise of port authority officials using a Delphi methodology.

The Delphi methodology was selected for obtaining a validated set of port authority objectives and scores associated to them. The applied Delphi approach worked in several steps. First, representatives from seven port authorities (Antwerp, Ghent, Zeebruges, Flushing, Rotterdam, Amsterdam and Genoa) responsible for green innovation were approached. All of them confirmed their willingness to verify a preliminary list of objectives as drafted by the authors of this paper. The comments and additions from the seven authorities were then processed in an updated version of the goals list. This new list was again submitted to the seven concerned authorities, for final commenting and approving. This led to a second updated objectives list, which was further used as basic list to apply the scoring.

Each case study has then been developed ensuring that the innovation selected is consistently ranked with the green objectives, so as to be able to assess the relative importance of the objective with respect to the action undertaken by the port authority. On the basis of these green success variables the team then proceeded to qualify each innovation with respect to the contribution to the PA objectives (and to the overall PA's green strategy). This approach is consistent with a focus on innovation, more than on individual ports. The steps necessary for filling in the ranking are listed below:

Step 1 For each port under study one or two specific actions connected with the environmental strategy of the port should be selected (e.g. reporting greenhouse gas emissions, or protect a certain type of flora in the port).

Step 2 Rank action 1 in terms of the objective it aims at achieving, on a 1 to 5 scale, where 1 is irrelevant, and 5 is very relevant (use table below, second column from the right)

Step 3 Within action 1 select a form of innovation (e.g. a new reporting form, or a new method to ensure flora redevelopment in the port)

Step 4 Rank the innovation connected to action 1 on a one to five scale, where 1 is unsuccessful, and 5 is very successful, against the objectives in view of how successful it is in achieving the target of the action (use table below third column

from the right).

Step 5 Repeat steps 2 to 4 for action 2 (columns 4 and 5 in the table below)

The data collection resulted in two separate rankings, one for the relevance of the objective for a specifically selected policy action and one for the success level of the innovation in achieving a targeted objective. The data has been analysed using a simple comparison of the results. In order to assess the consistency of the answer used, the homogeneity index H has been used for every objective.

The index H is a relative homogeneity index and is calculated as the standardized value of the square sum of the percentage frequencies of the ranking. So if we indicate as f_{ij} the percentage of innovation that ranked objective i with value j, with $j=1,\ldots5$. We can define the index h_i, as:

$$h_i = \sum_j f_{ij}^2$$

h_i has value as 1, when all innovations in the sample are given the same ranking (maximum homogeneity), and value $0.2=5*(0.2)^2$, when all innovations are ranked uniformly on the ranking scale (maximum heterogeneity). We can then define a relative homogeneity index as:

$$H_i = \frac{h_i - \min(h_i)}{max(h_i) - \min(h_i)} = \frac{h_i - 0.2}{0.8}$$

When H has high levels it indicates that the respondents gave the same ranking for the objective, while when the value of H is low, there is disagreement on the ranking of the objective.

3. GREEN OBJECTIVES

The following is a list of green strategic objectives against which the success for the innovation examples that have been selected for each port have been ranked. The objectives have been put together reviewing the main functions of port authority and investigating how environmental sustainability is likely to influence or interfere with each main port authority function. These functions are:

- The landlord function
- The regulatory function
- The operator function
- The community manager function

Since these objectives are by necessity rather generic, in every port and for both innovation cases a specific action was selected among those undertaken by the port authority. The green innovations are then ranked for every objective in the context of how much they contribute to achieve the targeted action.

3.1. Landlord function

The main strategic objective linked to the landlord function is to manage the areas and activities entrusted to the PA, specifically including the management, maintenance and development of the port estate, provision of port infrastructure and facilities, conception and implementation of policies and development strategies linked to the exploitation of the estate (e.g. port dues).

Table 1 – Landlord function.

Linked "Green objectives"	*Explanation*
Protect the port ecosystems	Protect the ecosystem in the port or neighbouring the port, including access channels, dredging, integral water management, soil, beaches, nature areas, etc.
Ensure environmental sustainability of the economic activities linked to the port	Limit the negative environmental effects of port economic activities, such as fisheries, tourism, cargo handling, power generation etc.
Create optimal space allocation and green recreational areas	Manage the balance between areas dedicated to economic activities and areas aimed at natural preservation or recreation
Include environmental considerations in the selection and management of tenants and in the selection of cargo traffic or ship fleet	Formulation of contracts and tendering agreements as well as overall policy aiming at limiting certain types of cargo or certain types of ships
Provide adequate waste reception facilities	Provision of waste reception facilities, waste management and adequate waste recycling
Attention for sustainable construction methods when building infrastructure	Include specific provisions in the construction specification of infrastructure
Ensure the use of space is optimised in master planning	Avoid as much as possible unnecessary use of space, or visual intrusion, community severance in the planning and development of port infrastructure
Include a environmental considerations in the planning and execution of connectivity policy and infrastructure	Development of hinterland transport strategies, including modal shift, congestion, traffic management, road, rail, etc. infrastructure
Adaptation to climate change	Any action taken to account for climate change induced impacts such as weather disruptions, flooding, etc.

Source: own compilation

3.2. Regulatory function

Within their regulatory function PAs aim at regulating the activities within the port, specifically including controlling, surveillance and policing functions in view of ensuring safety and security within the port but also concerning environmental protection.

Table 2 – Regulatory function.

Linked "Green objectives"	*Explanation*
Regulate environmental matters within the port	Port/harbor master regulation concerning pollution, waste management, energy efficiency, and any other environmental issues
Implement national/regional/global environmental regulation	Translate national/regional/global regulation into port regulation
Monitor pollution, including noise and emissions	Definition, adoption and use of any metrics aiming at monitoring external effects of port activities, such as air pollution, noise, water pollution, congestion, etc.
Sanction/prescribe emergency measures	Regulate with reference to emergency measures related to external effects of port activities, such as air pollution, noise, water pollution, congestion, etc. but also oil and dangerous substances spills.
Allow/prohibit activities within the port	Port/harbor master regulation prescribing what activities can be performed within the port areas
Reward/punish port operators over/under performing against specific environmental goals	Incentives and penalty schemes either within lease contracts or as voluntary actions, either at a port specific level or among various ports (e.g. Green-award)
Share information with reference to environmental compliance	Regulatory requirements to publish environmental reports, or to make such information available to the port authority, delegated agencies, or the public

Source: own compilation

3.3. Operator function

The operator function accounts for all the activities performed in the context of operating the assets within the port for profit (or non-profit), including physical transfer of goods and passengers between water and land, provision of nautical-technical services (pilotage, towage, mooring etc.), ancillary services, e.g. provision of onshore power for vessels.

Table 3 – Operation function.

Linked "Green objectives"	*Explanation*
Minimise impacts from operations	Any technical or operational action aiming at minimising the external impacts from operation such as air pollution, noise, water pollution, congestion, accidental oil and other substances spills

Improve energy efficiency and energy conservation within the port	Any technical or operational action aiming at reducing the energy consumption within the port, or the shift towards renewable forms of energy
Ensure operators include environmental considerations in the selection and management of subcontractors	Any contractual terms and conditions that aim at limiting the impacts from activities performed by subcontractors

Source: own compilation

3.4. Community manager

As a community manager the port's main purpose is to manage stakeholders' relations and manage the port community, structuring the port community and strengthening links between town and port and between port users, solving collective action problems in and outside the port area, mediate between conflicting interests in order to defend the 'license to operate' of the port, lobbying on different levels on behalf of the port community, providing incentives for port users towards more sustainable behaviour.

Table 4 – Community function.

Linked "Green objectives"	*Explanation*
Share information/increase visibility of green activities	Any action aiming at improving visibility of environmental information and/or any green project or action
Ensure coordination of environmental activities	Any action aiming at improving information exchange among actors and stakeholders with the objective of harmonising or coordinating activities
Market the port as green	Marketing and communication activities improving the environmental sustainability of the port
Ensure environmental awareness among employees of both the port authority and the port operators	Policy, campaigns, actions and activities targeting employees of the port authority, operators and delegated agencies with the objective of increasing environmental awareness or greener behaviours
Stimulate and facilitate port users in adopting green practices	Guidelines, handbooks, support activities, workshops etc. aiming at stimulating and facilitating the adoption of new technologies or environmental practices
Sustainable resource management	Any action aiming at facilitating recycling, scarce resource conservation (e.g. water, metals) and closing material loops within the port and along the chains involving the port

Source: own compilation

4. SELECTED PORTS AND THEIR GREEN INITIATIVES

Knowing the objectives that will be tested, the other side of the methodology asks for an overview of the innovation actions and concrete initiatives that will be tested, and for which specific ports that will be done.

4.1 Port of Genoa

The Port of Genoa is involved the 'Genoa Smart City' project; and so the first port in Italy to adopt a smog prevention plan. Its aim is a unique tool in Italy to promote renewable energy and energy efficiency in port areas. Next to it, the plan aims to convert the port of Genoa into a modern 'green port' thanks to new systems for solar, photovoltaic and wind power production and for quay electrification to be installed in port areas, with a potential reduction of about 20,000 tonnes of CO2 emissions by 2020.

Innovation 1: The Port Environmental Energy Plan (PEEP)

The Port Environmental Energy Plan (PEEP) aims at registering heat and electric energy consumptions of every port players in order to suggest/foresee possible interventions for reduction of consumptions. The plan dates back to 2010. PEAP also provides a wind power plant with 39 towers on the outer breakwater, 29 photovoltaic systems producing 5,600k and three thermal collectors on the roofs of buildings in the port area. Several applications for the installation of photovoltaic panels on the roof of buildings and warehouses have already been granted, in order to produce energy from solar radiation

Innovation 2: Quay electrification of ship repair docks

Quay electrification in the ship repair area of the port of Genoa will be the first step to prevent moored ships from running their auxiliary engines for a long time, thus emitting large amounts of greenhouse gases in the heart of the city (there are 12 berthing points), and to considerably reduce noise emissions in the area. Genoa Port Authority has already included the project – co-financed by Liguria Region, the Ministry of the Environment and Genoa Port Authority for a total value of about €15 million – in its environmental policy programme, expecting its completion by 2013. At the port of Genoa, quay electrification will reduce CO2 emissions by almost 10,000 tonnes every year, the wind power plant by 6,000 tonnes, the photovoltaic systems by 3,600 tonnes, and solar panels by 100 tonnes every year.

4.2. Port of Antwerp

Over 90 percent of European import and export of goods occurs by sea. As an important gateway to Europe, Antwerp is an important driving force for the economy. This is true at all levels: local, Flemish, Belgian and European.

Since the construction of the Deurganckdok, the latest major expansion of port capacity, the understanding has grown stronger that the European nature legislation is particularly important. Furthermore, sustainability, environmental sensitivity and for a sense of balance could easily be a competitive advantage in the future.

Innovation 1: Cold ironing

Shore power is already available for barges, as well as the Port Authority's tug and dredger fleet, floating cranes and dry dock complex, and will soon be supplied to pleasure craft and houseboats. Since 2009, also seagoing ships can be supplied - the segment that, in view of its size, has the most powerful effect on environmental performance

Innovation 2: Reinforcing market position

Antwerp has been one of the most important ports in the world for several centuries. It is currently the second largest port in Europe. To further reinforce this market leadership position, the port of Antwerp intends sailing an environmentally friendly stance.

Shipping companies have a number of good reasons to choose Antwerp. In future, an other element will be an environmental one. The Port Authority of Antwerp aims to play a leading role in achieving environmental targets both at European and Flemish and local level. In this way, the Port intends to leap forward towards a sustainable port. Therefore, it is needed to port users are rewarded when they make greater efforts than strictly is required. A corrective policy is required if they do not take their environmental responsibilities. This plan should re-inforce market share

4.3. Port of Singapore

Singapore is one of the cities with biggest progress in the last 10 years. Green businesses and clean technology are getting more attention in Singapore as the city strives to reduce its environmental footprint. The Maritime and Port Authority of Singapore aligns with this development and launched an initiative to promote environmentally-friendly shipping in Singapore. The initiative, called the Maritime Singapore Green Initiative, is aimed at combating greenhouse gas emissions from maritime shipping by committing S$100 million over the next five years into 3 core programs: the Green Ship Program, the Green Port Program and the Green Technology Program, each providing incentives across key maritime shipping segments. The latter two programmes are discussed more in detail.

Innovation 1: Green Port Programme

The Green Port Programme (GPP) was announced on 1 Jul 2011 under the Maritime Singapore Green Initiative to quicken ocean-going ships calling at the Port of Singapore to reduce the emission of pollutants like sulphur oxides and nitrogen oxides. Under this programme, 15% concession in port dues will be granted to those vessels that use type-approved abatement/scrubber technology or burn clean fuels with low sulphur content beyond MARPOL requirements during the entire port stay (of 5 days or less) within the Singapore Port Limits (from the point of entry into Singapore Port Limits till the point of exit). The

Green Port Programme is voluntary and will be valid for 5 years. Registration of vessels under the Green Port Programme (GPP) must be made using a valid Marinet account.

Innovation 2: Green Technology Programme

The Green Technology Programme inspires local maritime companies to develop and adopt green technologies. To co-fund the development and adoption of green technological solutions, this programme provides grants of up to 50% of total qualifying costs. Singapore-registered companies involved in maritime related businesses like terminal operations, ship owning and/or operations and harbour craft operations are eligible for the project.

Projects should also meet the following criteria:

- Have verifiable emissions (Sulphur Oxide, Nitric Oxide, Carbon Dioxide) reduction results that comply with industry performance guidelines.
- Have not been commonly deployed in the maritime industry.
- Should be type approved where relevant.
- Have system integration design and retrofitting

4.4. Port of Rijeka

Croatia´s leading port is undergoing transformation into a key maritime hub supported by access to TEN-Ts motorways and rail links, while logistics operations are rationalized by the Škrljevo dryport. Within this process, the development of an environmental management system is a very important for the Port of Rijeka Authority. The purpose of the Development of Environmental Management System (EMS) is to provide an EMS system, which will be implemented in the different area and facilities on the jurisdiction of the Port of Rijeka Authority. The EMS system is projected to facilitate finding and fixing the root causes of potential environmental problems and to improve environmental performance, prevent possible pollutions, conserve energy and natural resources. An EMS should focus on issues such as: water quality, air quality, waste management, habitat conservation, noise, contaminated soils, and energy consumption.

4.5. Port of Zeebruges

A restricted use of natural raw materials and the protection of the ecosystem are, together with the economic welfare and a well-balanced social development, the conditions for sustainable development. Zeebrugge enjoys a unique location between tourist coastal towns and valuable polder landscape. Several nature reserves are adjacent to the borders of the ports (de Baai van Heist, de Sashul, de Kleiputten van Heist, de Fonteintjes), or are even located inside the harbour area (het Sterneneiland, de Dudzeelse polder). By means of nature compensations (both inside and outside the port), the port authority becomes engaged to an active policy of

nature conservation, management of natural resources and nature recovery each time when new terrains of the port area are developed for economic activity. Zeebrugge also promotes itself as a green port with the presence of wind turbine arrays and cold ironing for the ships and the absence of polluting industry.

Innovation 1: Cold ironing

The port strives for being a Clean Port. After all, the pure environment also constitutes a commercial trump card for amongst others the food industry. Currently, the port authority is examining the ecological footprint in order to decrease the CO2 emissions.

Innovation 2: Wind mills

Aspiravi NV is operating 71 wind turbines + 25% 7 VLEEMO-windturbines. The total installed capacity of this wind-generated energy is 114,6 MW + 25% of 15 MW. Aspiravi Offshore NV is participating in the Northwind project and the projects developed by Otary e.g. Seastar and Rental. Once operational, the total installed capacity in the North Sea area will be 750MW.

4.6. Ports of Los Angeles / Long Beach

The Ports of Los Angeles and Long Beach are environmental sustainability leaders in the US. Environmental efforts began decades ago with programs to improve water quality and restore wildlife and habitat. More recently, the ports have focused on air emissions associated with ocean vessels, cargo handling equipment, trains and trucks. Many different strategies have been implemented, some by the port authorities and others by terminal operators. Still others were forced by state legislation. The selected strategies are developed and implemented by the port authorities.

Innovation 1: Vessel speed reduction program

The vessel speed reduction program (VSR) is a voluntary program that began in 2001. The program requested that ocean vessel reduce speed within a 20 nautical mile zone on approach to the ports. The purpose of VSR is to reduce air emissions. Each port implemented the program in its own way. The program began with a relatively high participation rate which then declined over time. Incentives offered in 2004 – 2006 resulted in increased participation. By 2007 participation was in the range of 80-90% and has remained at this level. Major incentives included berth labor pre-assigned so that docking and loading/unloading began immediately, and “Green Flag” recognition programs for shipping companies with very high compliance levels. Linder (2010) used compliance levels for 2002 and 2007 to estimate emissions reductions due to the VSR program. Estimated reductions were in the range of 40 – 50% for four criteria pollutants.

Innovation 2: Clean Truck Program

The Clean Truck Program (CTP) was implemented by the ports in 2006 as part of the ports' Clean Air Action Plan. The intent of the plan was to reduce port-related vehicle emissions by about 50% by 2010. The purpose of CTP was to reduce emissions from drayage trucks by replacing the entire drayage vehicle fleet with trucks that met 2007 federal Environmental Protection Administration standards. In order to enforce the program, all trucks were required to be equipped with RFIDs (radio frequency identification devices) and registered in the ports' Drayage Truck Registry. In order to provide an additional incentive a Clean Truck Fee of $35/TEU was to be charged to the beneficial cargo owner for any loaded container carried by a non-compliant truck. The CTP was extremely controversial, because it also required licensed motor carriers (trucking companies) to enter into concession agreements with the ports, and only those carriers would be able to operate at the ports. The effect of this requirement was to replace independent owner-operators with employee drivers. In response to lawsuits, in 2009 the Port of Long Beach withdrew the concession requirement. The Port of Los Angeles has maintained the concession model, but the matter remains unsettled as lawsuits proceed through the US court system. The CTP achieved its goals. By 2009, 75% of all drayage truck trips were compliant with 2007 EPA standards. According to the Ports, heavy duty diesel truck particulate emissions were reduced by nearly 90% by 2010.

4.7. Port of Hamburg

The Port of Hamburg has been in the forefront in terms of implementation of environmental policies, as a result of the proximity of the port to the city and the role of the city of Hamburg in steering the port authority decisions (Hamburg Port Authority is controlled by the Senate of the city of Hamburg). Important issues is the environmental policy of the port is energy efficiency and response to climate change, further exploitation of the railroad position within the port, harmonious development of the port with the city, wind power development, and the protection and management of the Elbe river ecosystem.

Innovation 1: Electrification of the Automated Guided Vehicles (AGVs) in the HHLA Terminal Altenwerder

The HHLA terminal Altenwerder is one of the most important container terminals in the port of Hamburg. The terminal operating company introduced in 2010 in cooperation with Gottwald, AGV's that are entirely operated through a battery. The new generation battery allows the vehicle to operate for 12 hours and automatically go back to the recharging station when power levels become too low. In the recharging station he battery is replaced and the vehicle is operational within a few minutes. The battery-driven AGVs (B-AGVs) can carry up to 60 tonnes and consume 19 kWh per hour of operation. The benefits are that not only the vehicles do not generate any emissions, but are also silent and allowed for substantial costs savings. The terminal is completely powered through certified green energy.

Innovation 2: Use of a Market Consultation for the definition of the project Central Terminal Steinwerden (CTS)

The future Central Terminal Steinwerden will be located in a central area within the port of Hamburg, now comprising of various basins and land areas. The terminal area will be approximately 125 ha on the water side and will be obtained dismantling existing facilities and filling various water basins. The final destination of the area is likely to be decided during 2013. In 2009 the Hamburg Port Authority launched an international market consultation with the objective of collecting ideas on possible uses of the area and alternative configurations. The consultation resulted in over 30 alternative proposals and shows the interest in such early stage consultations. In July 2010 the winner of the consultation (Royal Haskoning) was selected by an independent Jury. Among the criteria considered there were innovativeness of the approach to operations, how environmental aspects are handled and the feasibility of the financial models proposed.

5. RESULTS AND INTERPRETATION

The analysis provided two main outputs: an innovation success ranking and a ranking summarizing the relevance of the associated policy action with respect to a set of clearly defined green objectives. The ranking results are provided in the two tables below.

The results in the first table show that the innovation selected in the sample have been most successful in achieving the objectives in the categories of operator function and community manager function. Among the objectives listed under the category landlord function and regulatory function, there is more homogeneity among the scores, with most objectives scoring below 3.

The second table shows that actions are rather diverse with respect to the objectives that they target. Also in this case the objectives grouped under 3 and 4 are more heterogeneously ranked with lower scores, but higher average.

A possible interpretation of the ranking is provided by the analysis of how often an objective is indicated as successfully achieved by an innovation. This interpretation allows observing that independently of the innovation and of the port selected, certain objectives tend to rank higher than others. Such observation indicates that innovations are more successful in achieving some objectives than others, and that some objectives score higher more frequently in the sample.

The objective for which the innovation ranking consistently shows that it was successfully achieved is "*2.7. Share information with reference to environmental compliance*". This seems to indicate that such objective is more easily achievable independently from the port and from the type of innovation, or that all the innovation selected had aimed at fulfilling such

objective. If we compare this result with the relevance of the related action to such objective, we observe that the action is consistently ranked low, indicating that success in achieving such objective is probably incidental. It should be noted though that the degree of heterogeneity in the answer is also quite high in this case (almost half of the innovations score very low, but the remaining score 5 in this objective).

The next highest-ranking objectives are all belonging to the last group of objectives (category 4, community manager) and they are:

- 4.3. Market the port as green
- 4.5. Stimulate and facilitate port users in adopting green practices

Table 5 – Innovation success ranking.

Objective	Frequency of score						Prevailing score
	TL	1	2	3	4	5	
1. Landlord function:							
1.1. protect the ecosystems in the port or neighbouring the port	12	17%	0%	42%	17%	25%	3
1.2. ensure environmental sustainability of some of the economic activities linked to the port (e.g. fisheries, tourism,…)	11	9%	36%	18%	9%	27%	2
1.3. create green recreational areas	12	58%	17%	17%	8%	0%	1
1.4. include environmental considerations in the selection and management of tenants and in the selection of cargo traffic or ship fleet	11	18%	9%	36%	27%	9%	3
1.5. Provide adequate waste reception facilities	8	63%	13%	0%	25%	0%	1
1.6. Attention for sustainable construction methods when building infrastructure	8	38%	0%	25%	13%	25%	1
1.7. Ensure the use of space is optimised in master planning	8	63%	0%	25%	0%	13%	1
1.8. include environmental considerations in the planning and execution of connectivity policy and infrastructure	8	25%	13%	13%	38%	13%	4
1.9. Adaptation to climate change	8	38%	13%	13%	38%	0%	1;4
2. Regulatory function							
2.1. Regulate environmental matters within the port	11	27%	18%	18%	18%	18%	1
2.2. implement national/regional/global environmental regulation	10	30%	20%	30%	0%	20%	1;3
2.3. monitor pollution	10	20%	10%	30%	20%	20%	3
2.4. sanction/prescribe emergency measures	10	80%	20%	0%	0%	0%	1
2.5. allow/prohibit activities within the port	11	45%	27%	18%	9%	0%	1
2.6. reward/punish port operators over/under performing against specific environmental goals	11	36%	18%	9%	27%	9%	1
2.7. share information with reference to environmental compliance	11	36%	9%	9%	9%	36%	1;5
3. Operator function							
3.1. ensure minimisation of impacts from operations	10	10%	10%	40%	10%	30%	3
3.2. ensure energy balance within the port	11	27%	9%	27%	27%	9%	1;3;4
3.3. Ensure operators include environmental considerations in the selection and management of subcontractors	6	33%	0%	50%	17%	0%	3
4. Community manager							
4.1. share information/increase visibility of green activities	10	10%	10%	50%	0%	30%	3
4.2. ensure coordination of environmental activities	11	9%	9%	45%	27%	9%	3
4.3. market the port as green	11	9%	0%	18%	45%	27%	4
4.4. ensure environmental awareness among employees of both the port authority and the port areas	11	9%	27%	36%	18%	9%	3
4.5. Stimulate and facilitate port users in adopting green practices	6	0%	17%	33%	50%	0%	4
4.6. Sustainable resource management	6	17%	17%	33%	33%	0%	3;4

Source: own compilation

Table 6 – Objective relevance with respect to selected actions

Objective		Frequency of score					Prevailing score
	TL	1	2	3	4	5	
1. Landlord function:							
1.1. protect the ecosystems in the port or neighbouring the port	11	18%	0%	45%	18%	18%	3
1.2. ensure environmental sustainability of some of the economic activities linked to the port (e.g. fisheries, tourism,…)	10	0%	30%	10%	40%	20%	4
1.3. create green recreational areas	11	64%	18%	0%	18%	0%	1
1.4. include environmental considerations in the selection and management of tenants and in the selection of cargo traffic or ship fleet	11	9%	27%	18%	9%	36%	5
1.5. Provide adequate waste reception facilities	8	63%	13%	13%	13%	0%	1
1.6. Attention for sustainable construction methods when building infrastructure	8	38%	0%	0%	38%	25%	1;4
1.7. Ensure the use of space is optimised in master planning	8	63%	0%	13%	25%	0%	1
1.8. include environmental considerations in the planning and execution of connectivity policy and infrastructure	8	25%	25%	25%	25%	0%	1
1.9. Adaptation to climate change	8	38%	25%	13%	13%	13%	1
2. Regulatory function							
2.1. Regulate environmental matters within the port	11	18%	9%	9%	27%	36%	5
2.2. implement national/regional/global environmental regulation	10	30%	10%	30%	10%	20%	1;3
2.3. monitor pollution	10	20%	20%	20%	10%	30%	5
2.4. sanction/prescribe emergency measures	10	80%	0%	20%	0%	0%	1
2.5. allow/prohibit activities within the port	11	36%	18%	18%	18%	9%	1
2.6. reward/punish port operators over/under performing against specific environmental goals	11	27%	9%	36%	0%	27%	3
2.7. share information with reference to environmental compliance	11	36%	9%	18%	18%	18%	1
3. Operator function	0						
3.1. ensure minimisation of impacts from operations	11	9%	9%	18%	36%	27%	4
3.2. ensure energy balance within the port	11	27%	0%	36%	27%	9%	3
3.3. Ensure operators include environmental considerations in the selection and management of subcontractors	6	33%	0%	67%	0%	0%	3
4. Community manager							
4.1. share information/increase visibility of green activities	10	0%	10%	50%	10%	30%	3
4.2. ensure coordination of environmental activities	11	9%	9%	55%	27%	0%	3
4.3. market the port as green	11	0%	0%	27%	36%	36%	3;4
4.4. ensure environmental awareness among employees of both the port authority and the port areas	11	9%	36%	27%	18%	9%	2
4.5. Stimulate and facilitate port users in adopting green practices	7	0%	14%	43%	29%	14%	3
4.6. Sustainable resource management	6	17%	17%	33%	17%	17%	3

Source: own compilation

Many of the innovations that are ranked as successful are then linked to the function of community manager for the port. From the action ranking it appears that actually the community manager function is in general at least partially also a stated objective of the action. In this case the scores are more homogeneous, although they tend to be more homogeneous for the innovation ranking than for the action ranking.

5.1. Landlord function

For the green objectives related to the landlord function we observe that the innovation selected do not appear to be particularly successful. The following objectives were consistently selected as important as action objectives, but none of these resulted in particularly high success rates from the innovation:

- *1.2. Ensure environmental sustainability of some of the economic activities linked to the port (e.g. fisheries, tourism,…)*
- *1.4. Include environmental considerations in the selection and management of tenants and in the selection of cargo traffic or ship fleet*
- *1.6. Attention for sustainable construction methods when building infrastructure*

The objectives for which though the innovation appears to be moderately successful (modal score 3) are:

- *1.1. Protect the ecosystems in the port or neighbouring the port*
- *1.4.Include environmental considerations in the selection and management of tenants and in the selection of cargo traffic or ship fleet*

showing that only the actions that targeted objective 1.4 where supported in achieving such objective by the innovation selected.

5.2. Regulatory function

Green objectives listed under the port regulatory function appeared to be relevant for several actions. In particular the objectives:

2.1. Regulate environmental matters within the port

2.3. Monitor pollution

are listed as relevant for 40% and 33% of the actions in the sample. Also in this case, this importance is not supported by the innovation success ranking. The innovations in the sample do not appear particularly successful in achieving these objectives, with the exception of the objective 2.7. Share information with reference to environmental compliance, as mentioned before, for which 40% of the innovations are listed as very successful. Such objective, however, was not ranked as relevant with the selected actions.

5.3. Operator function

Among the objectives linked to the operator function of a port, objective '*3.2. Ensure energy balance within the port'*, seems the one for which the forms of innovation in the sample have been more successful. The stated action objective in this category is instead, as it was to be expected*: 3.1. Ensure minimisation of impacts from operations*.

5.4. Community manager function

As mentioned above, there is a certain degree of consistency between the success of the sampled innovations in achieving the objectives listed under the community manager function and the frequency with which such objectives are ranked as relevant for the action definition. The success level though is not very high and neither is the relevance, implying that such

objectives are considered less crucial in the environmental strategy of the port and more incidentally achieved. This might be related to the fact that such function is based on soft type of activities, the success of which might be perceived as more easily attainable.

Table 7 – Comparison of action and innovation ranking prevailing scores (mode) and homogeneity indexes.

Objective	Action		Innovation	
	Mode	H	Mode	H
1. Landlord function:	22%	18%	11%	17%
1.1. protect the ecosystems in the port or neighbouring the port	3	12%	3	12%
1.2. ensure environmental sustainability of some of the economic activities linked to the port (e.g. fisheries, tourism,…)	4	13%	2	6%
1.3. create green recreational areas	1	34%	1	25%
1.4. include environmental considerations in the selection and management of tenants and in the selection of cargo traffic or ship fleet	5	6%	3	6%
1.5. Provide adequate waste reception facilities	1	31%	1	35%
1.6. Attention for sustainable construction methods when building infrastructure	2.5	19%	1	11%
1.7. Ensure the use of space is optimised in master planning	1	35%	1	35%
1.8. include environmental considerations in the planning and execution of connectivity policy and infrastructure	1	6%	4	7%
1.9. Adaptation to climate change	1	7%	2.5	15%
2. Regulatory function	29%	13%	0%	15%
2.1. Regulate environmental matters within the port	5	6%	1	0%
2.2. implement national/regional/global environmental regulation	2	5%	2	8%
2.3. monitor pollution	5	3%	3	3%
2.4. sanction/prescribe emergency measures	1	60%	1	60%
2.5. allow/prohibit activities within the port	1	4%	1	14%
2.6. reward/punish port operators over/under performing against specific environmental goals	3	10%	1	6%
2.7. share information with reference to environmental compliance	1	4%	3	10%
3. Operator function	33%	21%	0%	13%
3.1. ensure minimisation of impacts from operations	4	6%	3	10%
3.2. ensure energy balance within the port	3	10%	2.7	4%
3.3. Ensure operators include environmental considerations in the selection and management of subcontractors	3	45%	3	23%
4. Community manager	17%	14%	50%	14%
4.1. share information/increase visibility of green activities	3	20%	3	20%
4.2. ensure coordination of environmental activities	3	24%	3	12%
4.3. market the port as green	3.5	17%	4	14%
4.4. ensure environmental awareness among employees of both the port authority and the port areas	2	6%	3	6%
4.5. Stimulate and facilitate port users in adopting green practices	3	14%	4	23%
4.6. Sustainable resource management	3	3%	3.5	9%

Source: own compilation

Table 3 shows the comparison of the two rankings. The Wilcoxon test was performed on the total ranking to verify if they could be significantly different. For the total sample, the test fails to reject that the median of the differences between the two rankings is zero. We therefore cannot say that the two total rankings are significantly different (at 0.01). If we approach the rankings though at a group objective level, we observe that the test indicates that for the objectives grouped under the landlord function, the rankings are significantly different (at 0.01). For the objectives listed in categories 2 and 4, the test fails to reject the hypothesis that the two rankings are significantly similar. For the objectives grouped under the operator

function, the sample is too small to run he test, but it would be unlikely that the two rankings differ significantly.

This comparative analysis shows that the rankings are not statistically different in general, implying that as far as the overall degree of success, there is accordance between the relevance of the objectives for a specific policy action and the success ranking. When it comes to the landlord function is appears instead that the innovation success rate is at variance with the relevance of the policy action, indicating that as far as the objectives listed in category 1 are concerned, innovation is not successful when the objective is identified as important.

6. CONCLUDING REMARKS

The present analysis looked at which green objectives appear to be achieved successfully more often and what are the green objectives that are typically associated with green environmental action performed by a port authority. Ideally, it was expected that the objectives that are priorities as part of a policy action, should also lead to forms of innovation that are successful. The analysis, based on an international sample of port cases, does not seem to support such conclusion entirely. There seems to be a divergence between the relevance of the stated objectives associated with a policy action and the level of success that the green innovations linked to such action are able to achieve.

Those objectives that appear most successful could either be easier to achieve or perceived as most important and therefore prioritized. Assuming the latter is true, a degree of consistency with the objectives selected as policy action would be expected. Green innovation therefore is not successful enough in those cases where it should be. The green innovation success is achieved incidentally, and in areas that were not prioritised in the policy actions.

The study looked at what objectives are targeted more often by the policy actions ranking and this is not significantly different from the innovation success ranking. For some objectives the success ranking and the relevance ranking are not always the same, showing that green port innovations are not always successful in what they target, although they can be successful in general on other (multiple) fronts. In particular for the objectives listed as part of the landlord port function, innovation success is significantly not aligned to action relevance.

While policy actions in the used sample were focusing on a variety of green objectives, objectives linked to the regulatory and the landlord port function seem to prevail. Innovation instead seems to be most successful when dealing with the function of the port as community manager or with the objective of sharing information with reference to environmental compliance.

An important suggestion emerging from the analysis is to address in the selection of green innovation project their actual success potential, on order to ensure that the forms of innovation supported are strategically aligned with the policy actions selected.

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Appendix 2 - Table used for the ranking

Objective	Action 1	Innovation1	Explanation/ comments	Action 2	Innovation2	Explanation/ comments
	Relevance action	Success ranking		Relevance action	Success ranking	
1. Landlord function						
1.1. Protect the port ecosystems						
1.2. Ensure environmental sustainability of the economic activities linked to the port						
1.3. Create optimal space allocation and green recreational areas						
1.4. Include environmental considerations in the selection and management of tenants and in the selection of cargo traffic or ship fleet						
1.5. Provide adequate waste reception facilities						
1.6. Attention for sustainable construction methods when building infrastructure						
1.7. Ensure the use of space is optimised in master planning						
1.8. Include a environmental considerations in the planning and execution of connectivity policy and infrastructure						
1.9. Adaptation to climate change						
2. Regulatory function						
2.1. Regulate environmental matters within the port						
2.2. Implement national/regional/global environmental regulation						
2.3. Monitor pollution, including noise and emissions						
2.4. Sanction/prescribe emergency measures						
2.5. Allow/prohibit activities within the port						
2.6. Reward/punish port operators over/under performing against specific environmental goals						
2.7. Share information with reference to environmental compliance						
3. Operator function						
3.1. Minimise impacts from operations						
3.2. Improve energy efficiency and energy conservation within the port						
3.3. Ensure operators include environmental considerations in the selection and management of subcontractors						
4. Community manager						
4.1. Share information/increase visibility of green activities						
4.2. Ensure coordination of environmental activities						
4.3. Market the port as green						
4.4. Ensure environmental awareness among employees of both the port authority and the port operators						
4.5. Stimulate and facilitate port users in adopting green practices						

4.6. Sustainable resource management						