Executive summary

Christa Sys (UA), Thierry Vanelslander(UA), Michele Acciaro (KLU), Claudio Ferrari (UGenova), Athena Roumboutsos (UAegean), Genevieve Giuliano (USC), Geraldine Knatz (USC), Rosario Macário (TIS) and Jasmine Lam (NTU)

Highlights

- International and interdisciplinary research
- 75 innovation cases. Two cases contain the opinion of multiple stakeholders, hence resulting in 84 assessments.
- Combines in a new context the application of four quantitative instruments with international insights regarding port innovations. A holistic approach!
- Misalignments exist between company strategies and success degrees
- PROFIT: Innovations are profit-driven
- PLANET: If a company is involved in many innovation cases, CO_2 emission reductions are obtained more incidentally
- PEOPLE: all innovations are successful in Complying with social and labour regulation
- TYPE OF COMPANY: Break-bulk terminals and trucking companies are those were more improvement is possible in aligning innovation efforts with strategy
- CLUSTER OF INNOVATION: success in innovation in inland navigation is often not directed at important objectives
- TYPE OF INNOVATION: in equipment-related innovation initiatives success scores are lower than the average, showing that in this type of innovation the companies interviewed evaluate the degree of success as rather unsatisfactory. This could be due to the fact that innovation initiatives in equipment tend to be rather specific and performance or efficiency improvements, given the circumscribed nature of the change brought about by the innovation, can be easily measured, somehow leading to a more critical assessment of these initiatives.
- The majority of the port-related innovation cases analyzed in this study are classified as incremental, that is they are implemented in small steps and tend not to affect radically operations and work processes. Those innovation initiatives show a comparatively lower degree of success in achieve

economic-related objectives, maybe as the result that in the interviewees' perception the economic gains obtainable from these innovation actions are too limited.

- Insufficient data available to conduct a cost benefit analysis, hence, a decision-making framework is developed
- A unique 'recipe' for innovation success does not exist
- As the type of innovation tends from incremental, to modular, to system, to radical more stakeholders in the supply chain need to be involved
- Capability in terms of knowledge is important to succeed, while in terms of financial input (in the particular sample) most champions relay on own sources of financing
- Market push drives innovation
- The innovation champion is crucial in the success of the endeavor

Co.Research: sharing knowledge and experience

Research work coordinated by the University of Antwerp, with involvement of an international consortium of universities (Annex 1) investigated how innovation answers the main challenges of the ports industry (notably between players of the supply chain). The research fits within the BNP Paribas Fortis chair Transport, Logistics and Ports, hosted at the University of Antwerp (Belgium).

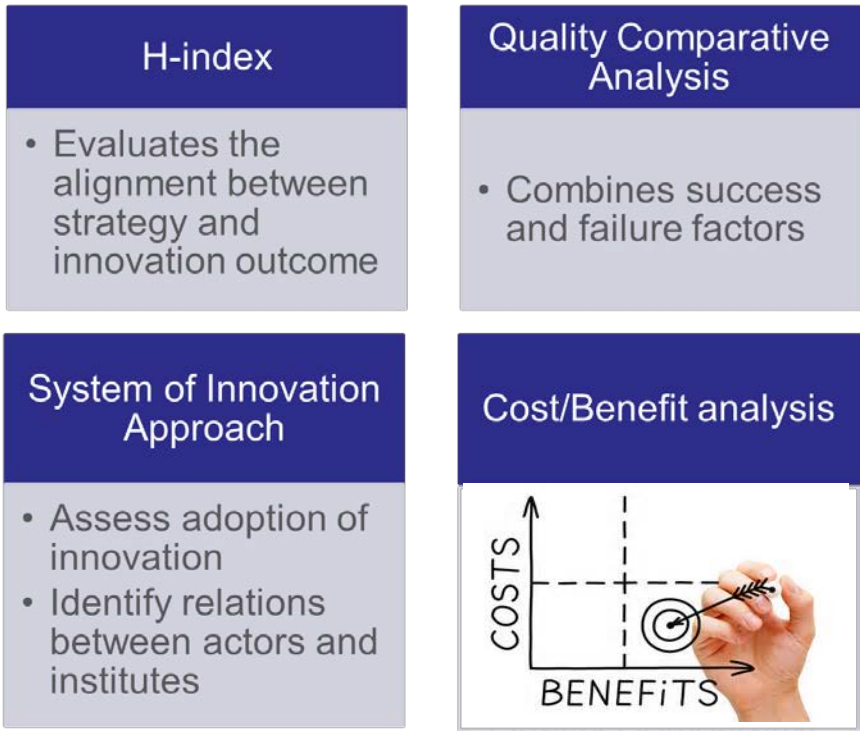
The research answers the following three questions:

- How can innovation answer the main challenges which the ports industry faces?
- Are there discrepancies in terms of innovation between various regions across the globe?
- Is the innovation success company-specific or rather context-specific?

Ultimately, the research identified future trends in port-related innovation and the way current innovations and innovation trends will be able to cope with those challenges, or whether new types of innovation will be needed.

First, Vanelslander et al. (2013) provide a synopsis of the recent port-related academic literature covering the 2011-2013 period. The authors find that the majority of port-related academic literature is limited to descriptive case studies. The present research combines in a new context the application of four quantitative instruments with international insights regarding port innovations. The application of these methodologies, by their joint application, helps understand the main patterns, characteristics, success factors and failure factors of port innovations, taking into account the context of the respective challenges, which prevailed when they emerged, and the goals they were planned to serve (economic, social and environmental). In addition, actor analysis and related costs and benefits seem to be a crucial element in the analysis. Ultimately, as some elements are more of a descriptive rather than a numeric nature, qualitative and quantitative approaches are combined (see Figure 1).

Figure 1: Overview of used methodology

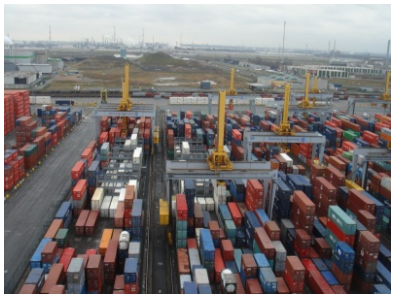


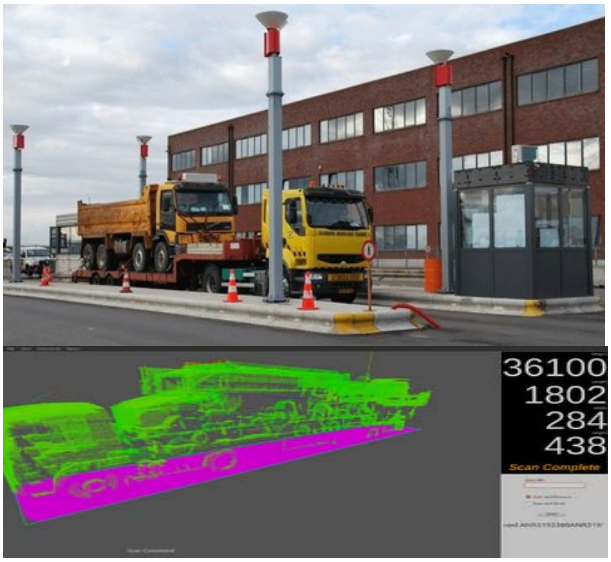
Secondly, case analysis allows forming an idea whether the maritime and port sector is preparing itself for new economic, environmental and social requirements. Over the 2013-2015 period, data for 75 innovation cases (Annex 2) was collected. Two innovation cases, namely the 3PL Primary Gate and Port Single Window, contain the opinion of multiple stakeholders, hence, resulting in 84 case assessments in total.

CO. Industry: staying competitive

About 30 private port operators located in 10 different countries contributed to the research by sharing their opinion and knowledge regarding (past, present and future) innovation cases developed by their company and/or in which they were involved. The participation of actors like shipyards (NL), shipping companies (BE, SG, GR, USA), deep-sea terminal operators (container (BE, IT), multipurpose terminal operators (BE, GR)) (BE, IT, SG, GR, USA), port authorities (PT, BE, SG, GR), stevedores (BE, NL, ES, FI), inland shipping companies (BE, FR), inland terminals (BE), freight forwarders (BE), rail operators (IT), container leasing companies (BE, NL), land transport companies (BE, USA), agencies (BE), and shippers (BE), covers the entire supply chain (Annex 3). Analyzing the split per country, a quite global coverage is found.

During the data collection, it was soon clear that if a company is innovative and creative, it works on different / continuous innovative initiatives.





Of the six possible types of cases, the majority (85%) turns out to be of a mixed technological, managerial, organizational and cultural nature, with either a market change impact (38 cases) or a business change impact (37 cases) across the entire supply chain. This most likely also confirms that purely technological innovation does not occur that often. To a lesser extent, that is also true for purely managerial, organizational and cultural innovation without clearly visible technological component. Many companies put innovation cases that are related to the cargo flow and ICT high on the agenda. Yet, the majority of the gathered initiatives are private commercial innovations. Furthermore, the mainstream of the cases are of the type 'incremental' innovations, that are based further developments of existing practices. (Table 1)

Table 1: Overview of innovation cases

Type of innovation	I Technological - unit change	a primarily technological change occurring at one specific location and/or for one specific operator	25
	II Technological - market change	Idem I but the change occurs for an entire product market (e.g. container handling)	0
	III Technological, Managerial, Organisational, Cultural – Business Change	Next to technological, the innovation also allows for changes at managerial, organizational and cultural level, all of those at the level of a specific business (e.g. handling coal transiting from Brazil to Europe)	12
	IV Technological, Managerial, Organisational, Cultural - Market Change	Idem IV but the change occurs for an entire product market	25
	V Managerial, Organisation, Cultural - Market Change	innovation into the organisational culture and management proce	9
	VI Policy Initiatives (Managerial, Organisation, Cultural – Market Change)	Policy-initiated innovation actions, which in turn may trigger furt	4
Type of change	Business change		37
	Market change		38
Implementation level	initiation		19
	development		13
	implementation		43
Innovation access	close	the tendency to keep innovation activities within the firm or cluste	28
	open	exchanging knowledge with the external environment	36
	semi-open		11
Innovation source	private		57
	public-private		8
	public		10
Degree of innovation	Incremental	a small change to existing products/procedures	30
	System	multiple independent innovations	19
	Modular	a significant change in concept within a component	16
	Radical	a breakthrough in the specific field	10
Innovation timing	past		11
	past/present		1
	present		39
	present/future		7
	future		17

CO.Results

Methodology 1: Misalignments exist between company strategies and success degrees

The first methodology, the I-index, looks at what determines innovation success and investigates how it is achieved in the shipping and port sectors. The latter is done by ranking the innovation case for success and importance along 34 strategic objectives subdivided in three main categories (economic, environmental and social)(Annex 4). Through the use of data collected for 69 innovation cases, the paper analyses the degree of alignment between innovation strategy and outcome across and within companies.

The results of the I-index indicates that substantial misalignments exist between company strategies and success degrees in the maritime and port sector and that efforts should be made to improve the strategic processes that lead to innovation in these industries. In some cases, it appears that success is achieved for those objectives that are not perceived as critical by the firm (incidental success), as for noise, CO_2 and air pollution reduction, while in other cases innovation fails to achieve important objectives (innovation failure), as in the case of differentiation from competitors or improving document management.

As far as the interpretation of the specific objectives is concerned, for all innovations, the homogeneity index equals 42 for economic added value, 72 for environmental impacts & climate change and 60 for social added value (expressed in average terms).

The closer is the I score to 0, the higher are the similarities among the innovations. Thus, the subdivision into three major objective categories, namely economic value added, environmental impacts and climate change, and social value added seems to be meaningful. Economic objectives appear to be ranked higher in terms of importance than the other objectives. However, for those objectives innovation does not achieve comparable degrees of success. This could be due to the use of more quantitative measures to assess success of innovation in the economically driven innovation processes. CO_2 reduction instead, being a common metric, is present as a parameter in many innovation cases. Air pollution reduction and CO_2 emission reductions are obtained more incidentally than the other objectives.

Social and environmental objectives seem to be achieved, but often are ranked as not important, suggesting that innovation success, when achieved, is often incidental. Virtually all innovations are successful in *Complying with social and labour regulation*, which is also perceived as an important objective.

In fact only 51% of the innovations surveyed showed an identical score between success and importance ranking. 26% reported a negative score, implying that for that innovation success was higher than the importance attributed to the objective, while 24% showed that the degree of success was perceived as lower than the importance attributed to this objective.

Operation optimisation and service improvements are the most highly ranked objectives, while *recycling*, *compliance with social and labour regulation* and *VAT transfer,* appear in this sample not to be the

primary focus of innovation. In terms of success the objectives that have been achieved most frequently are *obtaining first mover advantage* and *differentiation from competitors*. Among the lest frequently achieved objectives are objectives in the social and environmental categories, such increase employment, reduce water/soil pollution and improve management of waste. This could be related to the fact that these objectives are very specific and therefore only a few innovation initiatives in the sample were targeting them.

Decision rule	I<0 indicate that innovations are **successful** in tackling objectives of **little importance**	I = 0 indicates that innovations are **successful** in tackling important objectives	I>0 indicates that innovations are **unsuccessful** in tackling **important** objectives

Table 2: I index results among company types.

	Econ.	Environ.	Social	Average
All companies	3%	-4%	-4%	-1%
Trucking companies	10%	2%	2%	5%
Terminal operators	8%	-2%	-5%	2%
Ports	2%	-3%	-7%	-1%
Ship operators and shipping companies	-1%	-7%	-1%	-2%
Inland terminal	-2%	-3%	-1%	-2%
Break-bulk terminals	-8%	-2%	-17%	-8%
Other	9%	-11%	0%	0%

Source: author on BNP Paribas Fortis *case data.*

Findings: in the sample of innovation cases, the company with the major difficulty in achieving innovation in important objectives are trucking companies followed by terminal operators (Table 2). Break-bulk terminals, ship operators and shipping companies, as well as inland terminals show success in achieving objectives that are not considered to be important, while a difference is there with terminal operators and ports, where the main difficulty seems to be achieved in the area of economic objectives, whereas social and environmental objectives are achieved although they are not considered critical. This is in line with the findings of Acciaro et al. (2013) that came to the same conclusion for environmental objectives in ports.

Table 3: I index results grouped by innovation typology.

	Econ.	Environ.	Social	Average
All types of innovation	3%	-4%	-4%	-1%
Equipment innovation	-2%	0%	0%	-3%
Electronic data interchange innovation	-1%	-5%	-3%	-2%
Inland navigation innovation within urban context	-13%	0%	0%	-13%
Space innovation	14%	-3%	-4%	5%
Innovation in dredging	35%	-15%	10%	14%
Innovation supporting efficiency in loading/unloading	3%	-1%	-9%	-1%
IT innovation supporting the cargo flow	-3%	0%	-11%	-3%
Management innovation	4%	-3%	-2%	1%
Monitoring innovation - vehicles & cargo	-1%	-3%	-2%	-2%
Technological innovation - reducing operating vehicle costs(*)	NA	NA	NA	NA
Technological innovation supporting the transfer of containers from one mode to another	7%	-1%	2%	3%
Technological innovations supporting inland waterways	-23%	-23%	-22%	-19%

Source: author on BNP Paribas Fortis *case data*
(*) too few innovation cases.

Findings: *Innovation in dredging* seems to be the category of innovation where innovation fails to achieve important objectives (Table 3). This is, however, likely to be related to the very strict requirements that are used for such innovation, where a particularly critical assessment method has been used.

Inland navigation innovation within urban context, and *Technological innovations supporting inland waterways* seem to be the categories of innovation that achieve success incidentally.

Area	Cargo and IT flow	the general pattern of failure in economic objectives and incidental success on environmental and social objectives is observed
	Equipment	For all objectives there is a lack of success (related to the more accurate figures that are often used in assessing the outcomes of innovation in equipment)
	Other	
Level	Initiation	better results are achieved in the initiation phase of an innovation
	Development	there is a predominance of incidental success
	Implementation	among economic objectives, there is the prevalence of important ones that are not met satisfactorily
Nature	Radical	radical innovations achieve success incidentally
	Modular	modular, system and incremental innovations follow the pattern of showing more difficulty in achieving success for economic objectives
	System	
	Incremental	

Methodology 2: Cost/benefit-based decisions, or… external pressure?

A traditional cost benefit analysis (CBA) was not used by the companies or organizations that implemented these 75 innovation cases. Furthermore, in the cases examined it was not possible to collect data that was sufficiently reliable to undertake a complete cost-benefit analysis. A review of the literature supports the finding that port-related decisions for innovation cases are rarely based on formal cost-benefit analysis. This has to do with the fact that the traditional factors that compel the implementation of CBA were not present in most cases, and that the full range of benefits from the innovations were difficult to accurately monetize. A key objective in the completion of CBA is for public agencies to compare the benefits and costs of competing projects when determining the allocation of scarce funds. Given that the outcomes of these innovations are both uncertain and unique, they are less suitable for the application of CBA techniques.

Most cases had no associated cost-effectiveness data, while limited cost-effectiveness data was available for 8 of the 75 cases. Three (USA (2), BE(1)) of these 8 cases had public subsidies which may have influenced the type of data collected and also prompted public disclosure of the data. In these cases, the government innovation champion wanted to showcase the innovation as a model for others to follow.

For example the cost of constructing and operating a seawater emissions scrubber on an APL containership was tested to compare the cost effectiveness of complying with an IMO emission control area by using higher compliant fuels or lower cost non-compliant fuels with scrubber treatment.

The data also indicated that, in the cases where limited quantitative assessment of the innovation was undertaken, the data was collected concurrent with or after implementation of the innovation. Thus, collecting cost-effectiveness data was one objective of carrying out the innovation. This data could potentially be used as an input to perform a CBA for future implementation of the innovation. Another potential obstacle is that companies may not be forthcoming with their cost-effectiveness data for proprietary reasons.

With little quantitative data on cost-effectiveness, the 73 cases were reexamined to develop a framework for the decision-making. What prompted these 73 entities to undertake these innovations? Each innovation was categorized as 1) an internal decision made by the company for its own profit or efficiency motives; 2) an internal decision but influenced by external forces that created incentives or disincentives for the company; or 3) a response to a significant level of public subsidy. The data indicates that 36 or 49.3 % of the projects were undertaken because of external influences, 21 or 28.7% were purely internal company decisions and 16 or 21,9% were influenced by public subsidy. The public subsidies were also actions undertaken by governments to be responsive to community or environmental concerns. Therefore, of the 73 cases, 52 or 71.2% (category 2 and 3) were influenced by external forces.

This suggests that the port industry might consider being more proactive in examining innovations rather than, as in some cases examined, waiting until community and environmental pressures make innovation a necessity. There may be benefits that companies could realize by use of cost-benefit or cost-effectiveness analysis either to be more proactive in implementing innovation, to present a compelling case for government grants or subsidies, or in the case that the benefit/cost ratio would not be positive, to demonstrate to stakeholders why a particular innovation is not being implemented.

Table 4: Decisions-making spreadsheet

Category	Examples	Objective	Decision process	Number of cases
1 Internal decision, no external incentives or disincentives	Terminal appointment system Automated stacking cranes	Increase productivity, throughput, efficiency	Firm	21 or 28.7%
2 Strategic internal decision, external incentives or disincentives, no public subsidies	Use AF dock equipment as part of green port program Restore natural habitat as part of green port	Increase public support, pre-empt regulation, protect business interests	Firm, sometimes with stakeholder input	36 or 49.3%

or regulation	program			
3 Responsive decision to public subsidies or regulation (responses to subsidies different from responses to regs)	Subsidies for short-haul barge Scrubbers on ships	Reduce externalities, comply with regulatory requirements	Firm, government, other stakeholders	16 or 21.9%

Methodology 3: Combining conditions: no unique recipe

If only a limited amount of information is available per innovation case, a good method to deal with such situation is the Qualitative Comparative Analysis (hereafter QCA). This third method keeps the middle between a qualitative and a quantitative approach. Variables in this paper on innovation will be a combination of innovation success / failure factors and actors. They belong to three stages through which an innovation initiative usually develops (initiation, development and implementation).

This approach allows assessing, 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.

Of the total set of cases, 40 innovation cases were retained from the sample for which the success levels could be identified. Success is measured based on a weighted average of a set of economic, social and environmental criteria, scored by the interviewed companies. With the entire set of 40 cases, it turns out that no unique 'recipe' for innovation success does exist. However, some combinations of variables can be identified that lead for certain groups of cases to a higher chance of success. Overall, important variables turn out to be infrastructure, soft-institutional en hard-institutional issues at the initiation stage, and infrastructure at the development and implementation stages. The open or closed character of an innovation does not seem to have an impact.

With the entire set of 40 cases, no combination of conditions consistently leads to success. The innovation success rate is being measured and ranked using a combined indicator of the importance of the innovation initiative's objectives and their success rates. The so-called weighted success average by the importance combines both the importance of the objectives at the beginning of the project and their success rate when it was implemented.

The research shows that groups of cases typically feature common conditions which, when combined, give them a higher likelihood of being successful. All four identified groups seem to be composed of both 'technical' (physical) innovation as well as 'EDI' (virtual) innovation. Hence, the latter is not a distinguishing criterion.

The groups however are not fully separate: it appears that the same cases come back in several groups (grey marked). Also the same company, with different cases, sometimes comes back in various groups. It

seems then that there is more than one combination which turned that innovation into a success, or reinforced the success.

Terminal	Shipping line	Soft institutional	champion infra + hard institutions
-DP World Tandemlift Operations			
-Barge heavy lift ro/ro			
-10.6 feet high container			
-AET Autotrakker			
-Leixões Port - 3PL - Primary Gate			
-Alfaport Seagha			
-Alfaport APCS			
-DP World EDI		-DP World EDI	
		-DP World Automated stacking cranes	
			-DP World Truck appointment system
-Arcelor IT Data Exchange			
-Grupo Nogar all-weather terminal			
-Port of Kokkola all-weather terminal	-Waterland all-weather terminal	-Waterland all-weather terminal (3)	-Waterland all-weather terminal
			-Wijngaardnatie all-weather terminal
-ACB Group Sea45 concept			
	-IHC DODO		
	-IHC Dredge pumps		
		-IHC Flexible spud wagon	
		-Metallo modal shift	
		-Efficiency leadership	
		-MSC e-transit	-MSC Extended Gate 1.0

Methodology 4: Actor analysis

Ultimately, in addition, actor analysis and related costs and benefits are a crucial element in the study. To do this, the Systems' of Innovation Approach is a powerful tool, as it is used to identify:

- Conditions in the innovation system that need to be present in order to successfully implement an innovation. The SIA also may assist in indicating which institutions and input to foster and when in the innovation adoption process, so as to enhance efficiency and avoid over- and under-spending of resources.

- Why innovation fails, even when the cost-benefit assessment has justified its implementation or even though it contributes to business strategies. In this aspect, the methodology is complementary to the other analyses carried out under this project on Port Innovation.

The Systems' of Innovation Approach with respect to the assessment of the adoption of innovation seeks to identify relations between actors and institutions within the innovation (adoption) system that contributes to innovation uptake or hinders it. While carrying out the analysis, it is assumed that the innovation considered is ex-ante expected to produce efficiency either as profit (or welfare) or as

competitive advantage in support of respective strategies. Therefore, the emphasis of this analysis is placed on stakeholder (actor) interactions and drivers within the innovation system required to overcome challenges to "change". The analysis is qualitative and seeks to identify actor inter-relations on the basis of infrastructure requirements, hard (laws and regulations) and soft (values and social behaviour) institutions, weak and strong networks (actors which are loosly or strongly inter-related by choice), capabilities (knowhow, competences, financing capability) but also with respect to factors exhibiting external influence on the innovation system such as market demand, competition and others. Actors include all identified and active stakeholders interacting in the innovation system. This study identifies deficiencies and drivers in the innovation system. The Systems' of Innovation analysis is best suited to analyse the case of a failure to identify the reasons behind the lesser outcome or the initial stages of the introduction of any innovation so as to create the best conditions within the system to secure successful adoption.

The present analysis after assessing the type and stage of innovation, takes advantage of the large number of cases (75) in the project sample, most of which have been successful and financed by the innovation champion. This allowed for (1) contextual assessment of actors involved and identification of key external drivers and (2) hypotheses testing.

The contextual analysis provided initial confirmation that similar actors are involved under the same contextual group as well as that the number of actors involved increases as the innovation level tends from incremental to modular to system to radical.

Four basic hypotheses were tested concerning:

1. The importance of capacities (external knowledge and financing)
2. The accord of all actors involved,
3. The importance of market push and
4. The ability of the innovation champion to influence actors and outcome.

The first hypothesis is fundamental in the linear theory of innovation uptake. While in most cases the presence of external knowledge capability was observed, there are indications that this was not a determining factor of success or failure. Financial support was absent in most cases and in the majority of cases self-financing was the preferred /adopted solution. The fact the first hypothesis did not "explain" outcomes puts special emphasis on the following three hypothesis, which are fully embedded in the Systems Innovation Approach. All three proved valid. In depth investigation of exceptions highlighted the impact of "market demand" and "port competition" and most importantly "innovation competition". The latter is also responsible of a lock-in effect and deserves further research, as well as the effects innovation systems have on each other.

The present sample of cases did not allow researching the effect actors' relations (weak and strong networks) may have on the innovation uptake. This also remains for further investigation and research.

Finally, once again, the innovation promoter / champion was found to be crucial in overriding potential setbacks (see hypothesis 4). Notably the promoter is better positioned when also the major beneficiary.

Further research, however, is also required with respect to this topic, looking into failed efforts to implement innovation.

The present sample of cases did not allow the investigation of actors' relations (weak and strong networks) and how these may influence innovation uptake. This also remains for further investigation and research. Further research is also required with respect to the topic of failed cases and the role of the innovation champion. "Innovation competition" figured as a potential reason behind lock-in effects and deserves further research, just like the effects innovation systems have on each other. Finally, the specific sample provided some insights with respect to "imitation" (as opposed to innovation). These cases deserve further investigation too.

Context analysis

Context	Number of Cases	Highlights
Technological Innovation Reducing Operating Vehicle Costs	3	▪ Strong presence of the innovation provider, also holding the respective knowledge capacity.
Innovation supporting the transfer of containers from one mode to another	5	▪ Strong support from all directly involved actors (innovation champion, innovation provider, employees and financing).
Innovation supporting efficiency in loading/unloading	11	▪ Incremental innovations with a modular character ▪ Market push is present in all cases. ▪ Capability (knowhow) important. ▪ The initiator (champion) varies as the efficiency of the loading/unloading activity benefits many actors involved. ▪ Financiers can identify the efficiency gain.
Technological Innovation supporting Inland waterways	3	▪ As above
Innovation in dredging	4	▪ Market push ▪ Innovation competition
Container Innovation	4	▪ Market push ▪ Collaboration of all actors in the supply chain
IT Innovation supporting cargo flow	5	▪ Market push ▪ Competition is a driver ▪ Involvement of actors not directly involved in the port (municipalities and regulators)
Monitoring Innovation Vehicles & Cargo	6	▪ Involvement of large number of actors ▪ Market push ▪ Capability: o IT knowledge providers important o Knowledge of process more important
Electronic data interchange Innovation	20	▪ Market push ▪ Extended number of stakeholders (Customs agencies and regulators) ▪ Capability: IT developers ▪ Shipping lines opposed ▪ Lock-in effects of other EDI in place
Inland Navigation with urban context	2	▪ Municipalities involved
Inland Terminal Innovation	7	▪ Market push ▪ Large number of stakeholders ▪ In general, the innovation provides benefits for all
Management Efficiency	4	▪ Strong Leadership

Pattern recognition

#	Hypothesis	Testing Results	Exceptions: Reasons
1	Capability building is a prerequisite of innovation uptake. Capability as: ▪ Knowledge and expertise with respect to the innovation provided by research institutes, the innovation providers or other external actors and also as ▪ Financing contribution/interest from financing institutions.	▪ Knowledge & expertise are either employed or exist in-house ▪ External financial support in only 13 over 75 cases Result: Not conclusive	▪ Number Incremental innovations in the sample: ▪ Relative low investment ▪ Need to minimize the sharing of financial gains ▪ Private initiated innovations may wish to avoid lending transaction costs ▪ Risk averse nature of lenders
2	If all actors in the stakeholder network have a positive disposition, the innovation is adopted	Confirmed by 44 over 48 cases fitting the criteria.	▪ Modest market push ▪ Port competition ▪ Innovation competition
3	Strong Market Demand may change the perspective of negative stakeholders	Confirmed by 14 cases over 15 cases fitting the criteria	▪ Not all needed stakeholders were involved
4	The strength of the Innovation Champion will override internal opposition.	Confirmed by 7 over 8 cases fitting the criteria	▪ Innovation competition (technology mismatch)

Towards CO.Innovation?

The use of multiple methods and sources of data collection (in-depth and focus (group) interview) allow checking for trends in port-related innovation.

First, from the research, it becomes clear that the next step in the innovation process will be about initiatives that changes the viewpoint on innovation from only 'profit' to 'profit and planet' oriented. It will no longer be limited to the CO_2 reduction of logistics operations, etc. Next to the environment's perspective, the customer's perspective ('lean') will become more important. In future strategic and operational decisions, the integration of lean considerations in port related innovations will help reach benefits along the maritime supply chain.

Secondly, new IT-applications will allow moving faster. To do this, the concept of open innovation, already known in other sectors, must be applied more in the maritime supply chain. The case analysis already suggests that there is a benefit-cost for every stakeholder, however, the benefit is not yet seen; and therefore the willingness to pay is very low. The latter plays definitely in a sector with low margins. It may also be the driver behind evidenced support to imitation (Roumboutsos, 2015). Today, stakeholders are in a lock-in situation. In the previous decades, everyone understood that IT is an interesting development and made an own stand-alone IT-system. The latter systems do not match with other IT applications of other stakeholders. Clearly, there is a price tag to integrating the systems. From a game-theoretic approach, there is no willingness to co-operate (comparable with co-operation between ports). It can easily be explained by formalizing the cost and benefits of adopting the IT application in a payoff

matrix. The choice is simple: either to continue with the own IT system or to integrate the system. In contrast to the innovation champion (e.g. trucking company, carrier,…) , however, the entry costs of the follower are bigger than the benefits, hence the game stops. The argument of stakeholders involved turns to the discussion about data (ownership, availability, accessibility and modifiable). Some examples in inland shipping that do not get past the pilot phase are BIVAS (BE), a virtual marketplace for barge operators and shippers and Bargecloud (NL), a virtual marketplace for multimodal container transport. Then, an alternative approach is to wait for new technology (for instance cloud applications) or legislation/intervention. Here, there might be a role for the government. If the cost is lower than the benefit or everyone is in it from the beginning (openness and trust), the success of the innovative concept is higher.

Literature on this subject is fairly general rather than specific to a particular context, like the maritime supply chain. Clearly, there is no unique outcome of open innovation and it is more complex than just a shift from closed to open nature of innovation. Here, future research is needed to examine what framework can help generate successful open innovations. The framework of Paasi et al. (2012) is about defining the appropriate form of collaboration and managing knowledge and data sharing during and after the collaboration.

Until now, there are many studies about open innovation but empirical evidence is limited. In the current research, not enough cases were successful to make a distinction between open and closed innovation cases. (Vanelslander et al., 2015)

Some empirical insights can be adopted from Tidd (2014). It is all about resources. Here 'open innovation' should be more than exploring external sources and resources. It should be about CO.Innovation, which should not be seen as an end in itself.

It is more than repackaging of existing research in other sectors (Tidd, 2014). Based on two variables (i.e. partner variety and innovation funnel openness) Lazzarotti and Mazini (2014) identified four basic ways of collaborating: closed innovator, specialized innovator, open innovators and integrated collaborators. In the maritime supply chain, it should evolve towards that last type of collaboration.

A test in Italy shows that being totally open in innovation activities is not the only and most suitable option (Lazzarotti and Mazini,2014).

In the present research and context, the first attempts to work with an upstream and downstream stakeholder failed in their first attempt, only few were successful but as closed innovation in the next attempt. Opting for the real option approach is however advisable.

In addition, one might accept that there is a different role for every stakeholder. Gianiodis, Ellis and Secchi (2014) provide a typology describing four open innovation strategies, namely innovation seeker, innovation provider, intermediary (Port associations, Port authority) and open innovator.

Last, actor co-operation also seems an important trend. The SIA analysis confirmed this.

Future research

In the next stage, success and failure of innovations need to be studied from a supply chain network perspective. It can be analyzed if indeed there are (extra) competitive advantages in cooperation of various supply chain and how co-creation in innovation can help. Therefore, the value of innovations or improvements should be measured.

Indicators of how well the port industry behaves in terms of innovation level, both in time and in comparison to other economic sectors to measure the degree of innovation will be applied. Therefore, a composite indicator, which encourages a sustainable output of the innovation processes, must be used. The profit, people and planed should be the next framework for innovation developments. Future research will focus on collecting data for those indicators regarding innovation.

Regarding future innovations, it might be interesting to work on opportunities for these new port related developments. Insights are required in shipping and port markets of the future.

ANNEX 1: UNIVERSITIES INVOLVED

University of Antwerp

University of the Aegean

University of Genova

Kühne Logistics University

University of Lisbon

Nanyang Technology University

University of South-California

ANNEX 2: OVERVIEW OF INNOVATION CASES PER STAKEHOLDER

Innovation @ shipyard

Dynamic Operation in Dredging and Offshore
Dredge pumps
Flexible spud wagon
Wild dragon

Innovation @ deepsea terminal

Advanced Gate Automation
Administration replaced by EDI
Inland terminal
Automated Stacking Cranes
Weighbridges
Tandem lift operations
Straddle carriers from diesel to CNG
Truck Appointment System
Container terminal: bottleneck @ land side
Vado Ligure "Port gate"
Autotrakker
E-freight system "E-port"
Terminal carbon footprint tracking
Port community system PORTNET

Innovation @ carriers

E-transit
E-gate 1.0 and 2.0
Carbon footprint assessment
S-BEND on LPG carriers
Emission Scrubber on APL containership
Bulk carrier self-loading/unloading cranes

Innovation @ stevedoring

Central port community system for break-bulk sector
Setting up of KVBG
Heavy cranes
Vans from diesel to CNG
All-weather terminal (NL)
All-weather terminal (BE)
All-weather terminal (ES)
All-weather terminal (FI)

Innovation cases @ port authorities

Offshore Single Point Mooring
3PL - Primary Gate of Leixões Port
Port Single Window
Carbon footprint assessment of port of Piraeus
SEAGHA
APCS

Innovation @inland terminal

Paperless Customs flow: import - extended gate up to the end consumer
Paperless Customs flow: import - paperless NCTS pilot (Port of Antwerp)
Paperless Customs flow: Export - paperless until deep-sea terminal
Expansion OCR capabilities
Portal with clients
Pre-notification deep-sea terminals ROTTERDAM
Pre-notification deep-sea terminals ANTWERPEN
Port Wide Lighter Schedule Port of Antwerp
Barge slots
Corridor management system
Digital CMR
Empty equipment
Transferium
CY Meerhout
Efficiency leadership program

Innovation @ inland operators

Urban distribution using navigation water ways (goods)
Barge heavy lift Ro-Ro hybride
Urban distribution using navigation water ways (vehicles)
Pallet shuttle barge – PSB
Small Barges and reactivation of small inland waterways

Innovation @ transport modes

ECO Combi
Transport hub
Platform EuroTransCon (import export + re-use)
Vanhool ECO Chassis
CNG Class 8 Heavy Duty Drayage Truck

Other innovations

Metrocargo
10’6” ft. container
SEA45
Modal shift (Beerse)
Modal shift (Beverdonk)
Foldable container
IT data management

ANNEX 3:INDUSTRY INVOLVED

Industry	
Shipyard	IHC (NL)
Carriers	MSC Belgium (BE), NOL (SG), Star bulk (GR), Eltsons (GR), APL (USA), Chartwold (GR)
Port Authorities	Porto petroli di Genova (IT) and Ports of Sines (PT), Lisboa and Leixões (PT), Piraeus Port Authority (GR), Port of Antwerp (BE)
Terminals operators	DP World (BE), APMT (IT), AET (BE),Terminal Bruzzone (IT), Jurong Port (SG), PSA (SN)
Stevedoring	Wijngaardnatie (BE), Zuidnatie (BE), Waterland (NL), Gruppo Nogar (ES), Port of Kokkola (FI)
Barge operator	CTF (FR), Blue line logistics (BE), UA research: small barges (BE)
Inland terminal	BCTN (BE)
Road operator	Transport Joosen (BE), Calcartage(USA)
Other	
Logistics	Arcelor Mittal Logistics (BE)
Rail operator	Metrocargo (IT)
Forwarding agent	ACB agency (BE)
Shippers	Metallo (BE), Nike (BE - validation)
Customs	Ports of Sines (PT), Lisboa and Leixões (PT)
Container broker agency	Caru container (NL)
Research	UA (BE)
Software	Software developer consultant (PT), Software houses (BE)

ANNEX 4:OBJECTIVES

PROFIT 	**PLANET** 	**PEOPLE** 
Cost minimization	Reduction of CO2	Offer new employment opportunities
Optimize of operations	Reduction of air pollutants	Retain human capital
Gain market share	Minimize impact of activity on landscape (or proximity territory)	Improve relations with local communities
Obtain first mover advantage	Reduce noise	Reduce number of accidents
Avoid depletion of resources	Reduce congestion	Reduce fraud attempts
Positive impact on competitiveness	Reduce water/soil pollution	Improve the efficiency of security requirements
Growth (marketing)	Improve management of waste	Comply with social and labor regulation
Employment (substitution of labor by capital)	Recycling	Comply with safety regulation
Efficient use of resources (equipment, land, etc.)	Integrate other developments which have a sustainability orientation	
Differentiation from competitors	Comply with environmental regulation	
Increase scale of operations		
Improve energy efficiency		
Integration with other actors		
Offer larger and equitable access to service		
Encourage other investments		
Facilitate transfer of official documents		

ANNEX 5: DEFINITIONS

Institutions/ rules/ factors	Definition	Data collection	SIA Scope
Infrastructure	The physical infrastructure that actors need for functioning (such as IT, telecom, and roads) and the science and technology infrastructure may not be available hindering further development.	Infrastructure that was the object of the innovation process (software, equipment….)	Requirements in infrastructure
Hard Institutions	The failures in the framework of regulation and the general legal system to support the development of a new application.	Regulation and legal system framework regarding the specific innovation development	Legal and regulatory framework and standards in general influencing uptake
Soft Institutions	The failures in the social institutions such as political culture and social values that hinder the uptake of the innovation.	Political culture, cultural values, social aspects, economic influence, standards imposed by stakeholder or different groups.	As collected but not standards
Weak Networks	The lack of linkages between actors as a result of which insufficient use is made of complementarities, interactive learning, and creating new ideas. The same phenomenon is referred to as dynamic complementarities' failure.	Missing actor; actor that was missing from the innovation network itself; actor that should have been involved in the process with the result of accelerating the innovation (example "-2": minus scale means actor was not involved and the relation would have been rated at 2 as important (the stated value))	Describes the impact on the innovation uptake of weak network relations between actors involved.
Strong Networks	The 'blindness' that evolves if actors have close links and as a result miss out on new outside developments.	Actor was involved in the development process. Negative scale indicate a negative involvement towards the innovation project, while the positive scale indicate a positive involvement. The values indicate the strength of the relation. Example:"-3" means that actor was involved, had a strong connection with the project, but stopped the innovation process, "0" means that actor was involved but didn't influenced the process, "3" means that actor was involved had a strong connection with the project and it accelerates the innovation process.	Describes the impact on the innovation uptake of strong network relations between actors involved.

Institutions/ rules/ factors	Definition	Data collection	SIA Scope
Capacities	Firms, especially small firms, may lack the capabilities to learn rapidly and effectively and hence may be locked into existing technologies/patterns, thus being unable to jump to new technologies/business patterns. In an extension, it can also include financial capability.	Capacities that were put together by each actor: personnel involvement; financial capabilities, money invested; availability of time and/or knowledge.	The same
Lock-in effects	The inability of complete (social) systems to adapt to new technological paradigms. The inability of firms to adapt to new technological developments.	Action of reaching to a dead-end in a certain phase of the innovation process; answer to the questions: which actor had a lock-in effect? How important was the effect on the innovation?	Existing hold on ability to change due to previous commitments, investments, values etc.
Market Demand	This is an external factor creating a push for either endorsing a particular innovation or driving for further efficiency in order to maintain or improve market position.	Market is demanding for the innovation and which actor is demanding	The same
Competition (innovation)	Innovation is adopted to address certain aspects of operation efficiency. There may be competing innovations in this context. This is also related to lock-in effects.	Competition felt from other similar innovations.	The same
Competition (Port)	The adoption of innovation relies on the cooperation of many actors. Intra and Inter – port competition may create limitations.	Competitions felt from other ports' side.	The same.

REFERENCES

Acciaro, M., (2015, April 23th) Innovation in the maritime sector: aligning strategy with outcomes. BNPPF innovation event, Antwerp.

Roumboutsos, A. (2015, April 23th) Comparative Analysis of Cases: Systems' Innovation Approach, BNPPF innovation event, Antwerp.

Vanelslander, T., Sys, C., Acciaro, M., Ferrari, C., Giuliano, G., Kapros, S., Lam, J., Macário, R., Rashed, Y. & Roumboutsos, A. (2013) Port Innovation: definition and typology. Unpublished work.

Vanelslander, T., Sys, C., Carlan, V. (2015, April 23th) Innovation among seaport operators: a QCA approach for determining success conditions. BNPPF innovation event, Antwerp.