Executive summary

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Highlights

RESEARCH: International and interdisciplinary research

75 INNOVATION CASES: Two cases contain the opinions of multiple stakeholders, resulting in 84 assessments.

METHODOLOGY: Combines four quantitative instruments to offer insight in port innovations in international context. A holistic approach!

- H-index: Misalignments exist between company strategies and degrees of success
    - PROFIT: Innovation initiatives are profit-driven
    - PLANET: If a company is involved in many innovation cases, CO_2-emissions reductions are obtained more incidentally
    - PEOPLE: All innovations comply with social and labour regulations
    - TYPE OF COMPANY: Break-bulk terminals and trucking companies offer the greatest scope for improvement in aligning innovation efforts with corporate strategy
    - TYPE OF INNOVATION: success scores in equipment-related innovation initiatives are below average, suggesting that the companies interviewed generally evaluate the outcomes of these types of innovation as relatively unsatisfactory. This could be due to the fact that innovation initiatives in equipment tend to be rather specific. Moreover, performance and 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.
    - DEGREE OF INNOVATION: The majority of the port-related innovation cases analysed in this study are incremental, meaning that they are implemented in small steps and tend

not to have a radical impact on operations and work processes. These innovation initiatives exhibit a comparatively lower degree of success in achieving the stated economic objectives. This may be attributable to the fact that, in the interviewees' perception, the potential economic gains from these innovation actions are too limited.

- CBA: Insufficient data was available to conduct a cost benefit analysis. Hence, a decision-making framework is proposed
- QCA: There is no unique 'recipe' for innovation success
- SIA: As the type of innovation tends to go 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 rely on own funding
  - Market push drives innovation
  - The innovation champion is crucial to the success of the endeavour

Co.Research: sharing knowledge and experience

This research, co-ordinated by the University of Antwerp and conducted in association with an international consortium of universities (Annex 1), explores the extent to which innovation meets the main challenges facing the various players in the ports industry. It was carried out under the auspices of the BNP Paribas Fortis Chair for Transport, Logistics and Ports, hosted by the University of Antwerp (Belgium).

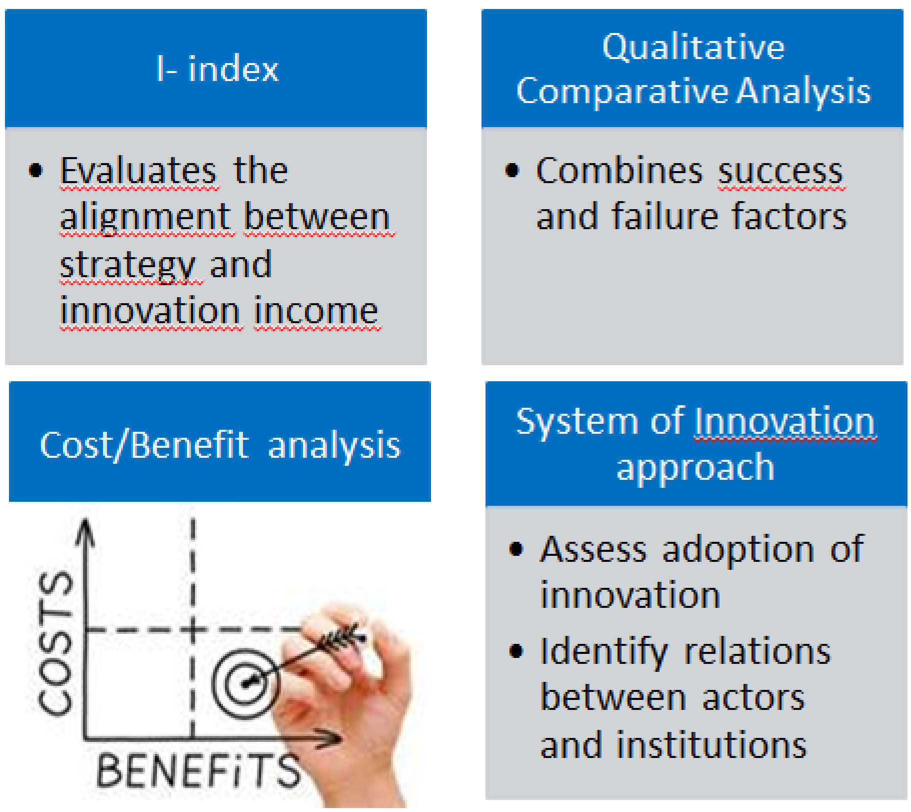
The research addresses the following three questions:

- How can innovation meet the main challenges facing the ports industry?
- Are there regional discrepancies in innovation across the globe?
- Is succesful innovation primarily company-specific or context-specific?

Ultimately, the research points at future trends in port-related innovation and how current innovations and innovation trends are likely to cope with the challenges ahead. It also identifies priority areas for further innovation.

First, Vanelslander et al. (2013) provide an overview 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 four quantitative instruments to attain deeper insight into port innovation around the world. This combined approach can help reveal the main patterns, characteristics, and factors for success and failure in port innovation, while also taking into account contextual factors such as the economic, social and environmental challenges and objectives. In addition, analysis of the actors involved and the associated costs and benefits would appear to be crucial to understanding the issues at hand. Ultimately, as some elements are of a descriptive rather than a numerical nature, qualitative and quantitative approaches must be combined (see Figure 1).

Figure 1: Overview of used methodology

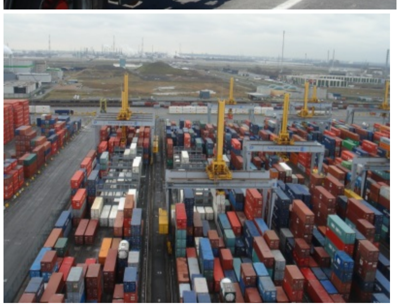


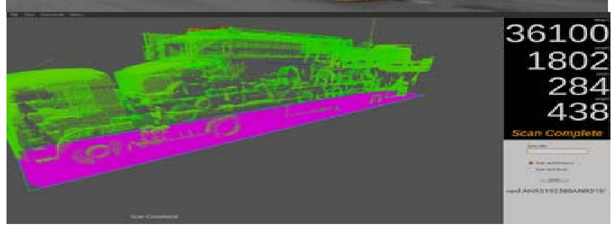
Secondly, case analysis allows us to gauge whether the maritime and port sector is preparing itself adequately for the economic, environmental and social challenges that lie ahead. Over the 2013-2015 period, data was collected on 75 innovation cases (Annex 2). For two innovation cases, i.e. the 3PL Primary Gate and the Port Single Window, we also gauged the opinions of multiple stakeholders, resulting in a total of 84 case assessments.

CO. Industry: staying competitive

About 30 private port operators located in 10 different countries contributed to the research by sharing their opinions and knowledge of (past, present and future) innovation drives in which they and/or their respective companies were involved. The participating actors included shipyards (NL), shipping companies (BE, SG, GR, USA), deep-sea terminal operators (container (BE, IT), multipurpose terminal operators (BE, IT)), 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). In other words, the research covered the entire supply chain (Annex 3).

During the data collection phase, it soon became clear that if a company is innovative and creative, it tends to be committed to various or to continuous innovation initiatives.





Of the six possible types of cases, the majority (85%) were found to be of a mixed technological, managerial, organisational and cultural nature, with either a market change impact (38 cases) or a business change impact (37 cases) across the entire supply chain. This would appear also to confirm that purely technological innovation is rather rare. To a lesser extent, so too are purely managerial, organisational and cultural innovation, without any clearly discernible technological component. Many companies put innovation that relates to the cargo flow and ICT high on the agenda. Yet, the majority of initiatives covered in our research are instances of private commercial innovations. Furthermore, the mainstream of the cases are examples of ‘incremental’ innovations, i.e. innovative projects that build on 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 processes without notable technological component	9
	VI Policy Initiatives (Managerial, Organisation, Cultural – Market Change)	Policy-initiated innovation actions, which in turn may trigger further innovation (e.g. introducing urban road pricing)	4
Type of change	Business change		37
	Market change		38
Level	initiation		19
	development		13
	implementation		43
Innovation access	close	the tendency to keep innovation activities within the firm or cluster of firms	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	20
	Modular	a significant change in concept within a component	16
	Radical	a breakthrough in the specific field	9
Innovation timing	past		11
	past/present		1
	present		39
	present/future		7
	future		17

Method 1: Misalignments between company strategies and degree of success

The first methodology, involving the I-index, analyses what determines success in innovation and investigates the extent to which it is achieved in the shipping and port sectors. To this end, we rank the innovation case for success and significance along 34 strategic objectives subdivided into three main categories (economic, environmental and social) (Annex 4). Using data on the 69 innovation cases, the paper analyses the degree of alignment between innovation strategy and outcome across and within companies.

The results of this exercise indicates that substantial misalignments exist between company strategies and degrees of success 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 objectives that are not perceived as critical by the firm concerned (i.e. incidental success), as in the case of noise, CO_2 and air pollution reduction, while in other instances innovation is found to fall short of achieving its prime 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 (H) equals 42 for economic added value, 72 for environmental impacts & climate change, and 60 for social added value (expressed in average terms).

The closer the I-score is to 0, the greater the similarities between the innovation initiatives concerned. Thus, the subdivision into three major objective categories, namely (i) economic value added, (ii) environmental impacts and climate change, and (iii) social value added, would appear 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 being a common metric, on the other hand, is present as a parameter in many innovation cases. Air pollution and CO_2-emission reductions are obtained rather more incidentally than the other objectives are.

Social and environmental objectives would appear to be achieved, but they are often seen to be of minor importance, suggesting that success in innovation, 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, in those cases, success was greater than the importance attributed to the objective, while 24% showed that the degree of success was perceived to be lower than the importance attributed to the objective concerned.

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 most commonly achieved objectives are *obtaining first mover advantage* and *differentiation from competitors*. Among the least frequently achieved are objectives in the social and environmental spheres, such as increasing employment, reducing water/soil pollution and improving waste management. This could be related to the fact that these objectives are very specific and thus they were put forward as targets in just a few of the innovation initiatives included in the sample.

Decision rule	I<0 indicates that innovation is **successful** in achieving **minor** objectives	I = 0 indicates that innovation is **successful** in achieving **major** objectives	I>0 indicates that innovation is **unsuccessful** in achieving **major** objectives

In the sample of innovation cases considered, the companies that find it most difficult to attain major objectives through successful innovation are the trucking companies, followed by the terminal operators (Table 2). The break-bulk terminals, ship operators and shipping companies, as well as inland terminals are successful in achieving minor objectives. Terminal operators and ports, for their part, seem to experience problems in achieving economic objectives, but less so in attaining social and environmental objectives, which are, however, considered less significant. This is in line with the findings of Acciaro et al. (2013) in relation to environmental objectives in ports.

Table 2: I index results by company type

	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: based on BNP Paribas Fortis *case data.*

Dredging emerges as the area where innovation is least likely to attain major objectives (Table 3). However, this is likely due to strict requirements imposed on innovation in dredging, where a particularly stringent assessment method is used.

Inland navigation innovation within urban context and *Technological innovations supporting inland waterways* are categories of innovation where success is achieved incidentally (Table 3).

Table 3: I index results by type of innovation

	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: based on BNP Paribas Fortis *case data*

(*) too few innovation cases.

Area	Cargo and IT flow	A general pattern of failure in economic objectives and incidental success in environmental and social objectives is observed
	Equipment	Lack of success in relation to all objectives (most probably due to stringent evaluation methods for equipment-related innovation)
	Other	
Level	Initiation	Better results are generally achieved in the initiation phase of an innovation
	Development	Mostly incidental success
	Implementation	Failure to meet major economic objectives
Nature	Radical	Incidental success
	Modular	Greater difficulty in achieving success in relation to economic objectives
	System	
	Incremental	

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

The companies or organizations implementing the 75 innovation cases did not conduct a traditional cost benefit analysis (CBA) in assessing their projects. Furthermore, it was impossible in the cases examined to gather sufficiently reliable data for undertaking such an analysis. The literature moreover suggests that port-related innovation decisions are rarely CBA-based. This is due to the fact that elements that typically necessitate CBA are often not present. Moreover, the full range of benefits from such innovations are hard to monetize accurately. CBA is commonly carried out in order that a public agency could compare the costs and benefits of competing projects before allocating scarce funds. Given that the outcomes of port-related innovations are both uncertain and unique, CBA techniques are less suitable for their assessment.

Moreover, in most of the cases considered, cost-effectiveness data was lacking; limited cost-effectiveness data was available for 8 of the 75 cases. Three (USA (2), BE(1)) of these 8 cases were publicly subsidized, which may have influenced the type of data collected and prompted their public disclosure. In these cases, the authorities championing the innovation apparently wished to showcase the innovation as a model for emulation. For example, in a project for the installation and implementation of a seawater emissions scrubber on an APL containership operating in an IMO emission control area, prior comparison was made of the cost effectiveness of using non-compliant fuels with scrubber treatment as opposed to using more compliant fuels.

If maritime innovators are not using CBA and are only using cost effectiveness analysis (CEA) to a limited extent, how are private innovators making business decisions whether or not to invest in a potential innovation? Seventy three of the innovation cases were re-examined for the purpose of constructing a framework for decision-making. What prompted these 73 entities to undertake these innovations? Each innovation was categorized as resulting from either 1) an internal decision made by the company for its own profit or efficiency motives; 2) an internal decision influenced by external forces that created incentives or disincentives for the company; or 3) a response to a significant level of public funding. The data indicate that 36 (49.3 %) of the projects had been prompted by external influences, 21 (28.7%) had resulted from a purely internal corporate decisions, and 16 (21.9%) had been induced by public funding, including as part of government action in response to community or environmental concerns (Table 4). Hence, of the 73 cases considered, no fewer than 52, or 71.2% (categories 2 and 3), had been prompted to some extent by external forces.

This suggests that perhaps the port industry should adopt a more proactive attitude towards innovation rather than to wait, as in some of the cases examined, until public and environmental pressures impose the need for innovation. In this context, cost-benefit or cost-effectiveness analysis could be useful in presenting a compelling case for government support or in demonstrating to stakeholders why a particular option for innovation is not being pursued.

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 (28.7%)
2 Strategic internal decision, external incentives or disincentives, no public funding or regulation	Use AF dock equipment as part of green port programme Restore natural habitat as part of green port programme	Increase public support, pre-empt regulation, protect business interests	Firm, sometimes with stakeholder input	36 (49.3%)
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 (21.9%)

Method 3: Combining conditions: no unique recipe

Qualitative Comparative Analysis (QCA) is a useful tool in cases where only a limited amount of information is available on the innovation concerned. This third method holds the middle ground between the qualitative and quantitative approaches. The innovation variables considered in this paper combine success / failure factors and the actors involved. These are related to the three stages that innovation initiatives tend to go through, namely initiation, development and implementation.

This approach enables us to assess which innovations will generate which chain impacts, which conditions will induce or inhibit innovation, and what government can do to stimulate innovation.

Of the total set of cases, 40 innovation cases were retained for which the success levels could be ascertained. Success is measured based on a weighted average of a set of economic, social and environmental criteria, scored by the companies interviewed.

It emerges from the entire set of cases that no unique 'recipe' for innovation exists. Nonetheless, some combinations of variables are found to increase the likelihood of success. In general terms, the most significant variables turn out to be infrastructure, soft and hard institutional factors at the initiation stage, and infrastructure at the development and implementation stages. The open or closed nature of an innovation appears to be of no consequence.

Considering the set of cases, it transpires that no combination of conditions consistently leads to success. The innovation success rate is measured and ranked using a combined indicator of the significance of the innovation objectives and the success rates achieved. The so-called weighted success by importance combines the perceived importance of the objectives at the beginning of the project and the success rate after implementation.

The research indicates that certain groups of cases typically feature common conditions which, combined, increase the likelihood of success. All four groups appear to be composed of both 'technical' (physical) innovation as well as 'EDI' (virtual) innovation. Hence, the latter is not a distinguishing criterion.

The groups are however not fully separate: the same cases occur in different groups. Such cases aremarked grey in Table 5. Also the same company, with different cases, sometimes comes back in various groups. It seems, then, that there is more than one possible combination for turning innovation into a success or for enhancing its degree of success.

Table 5: Decisions-making spreadsheet

<table>
<tr><th>Terminal</th><th>Shipping line</th><th>Soft institutional</th><th>champion infra
+ hard institutions</th></tr>
<tr><td colspan="2">-DP World Tandemlift Operations</td><td></td><td></td></tr>
<tr><td>-Barge heavy lift ro/ro</td><td></td><td></td><td></td></tr>
<tr><td colspan="2">-10.6 feet high container</td><td></td><td></td></tr>
<tr><td>-AET Autotrakker</td><td></td><td></td><td></td></tr>
<tr><td colspan="2">-Leixões Port - 3PL - Primary Gate</td><td></td><td></td></tr>
<tr><td colspan="2">-Alfaport Seagha</td><td></td><td></td></tr>
<tr><td>-Alfaport APCS</td><td></td><td></td><td></td></tr>
<tr><td>-DP World EDI</td><td></td><td>-DP World EDI</td><td></td></tr>
<tr><td></td><td></td><td colspan="2">-DP World Automated stacking cranes</td></tr>
<tr><td></td><td></td><td></td><td>-DP World Truck appointment system</td></tr>
<tr><td colspan="2">-Arcelor IT Data Exchange</td><td></td><td></td></tr>
<tr><td colspan="2">-Grupo Nogar all-weather terminal</td><td></td><td></td></tr>
<tr><td>-Port of Kokkola all-weather terminal</td><td>-Waterland all-weather terminal</td><td>-Waterland all-weather terminal (3)</td><td>-Waterland all-weather terminal</td></tr>
<tr><td></td><td></td><td></td><td>-Wijngaardnatie all-weather terminal</td></tr>
<tr><td colspan="2">-ACB Group Sea45 concept</td><td></td><td></td></tr>
<tr><td></td><td>-IHC DODO</td><td></td><td></td></tr>
<tr><td></td><td colspan="2">-IHC Dredge pumps</td><td></td></tr>
<tr><td></td><td></td><td>-IHC Flexible spud wagon</td><td></td></tr>
<tr><td></td><td></td><td>-Metallo modal shift</td><td></td></tr>
<tr><td></td><td></td><td>-Efficiency leadership</td><td></td></tr>
<tr><td></td><td></td><td>-MSC e-transit</td><td>-MSC Extended Gate 1.0</td></tr>
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Method 4: Actor analysis

Actor analysis and related costs and benefits are also a crucial element in the study. In this respect, the Systems-of-Innovation Approach (SIA) is a powerful tool, as it identifies:

- Conditions in the innovation system that need to be present in order to successfully implement an innovation. It may also be helpful in determining which institutions and input to foster and at which stage of the innovation process, so as to enhance efficiency and avoid over- or underspending of resources.
- Why innovation fails, even when cost-benefit assessment justifies its implementation or despite its adherence to corporate strategy. In this sense, the methodology is complementary to the other analyses conducted in the present study.

In the context of an assessment of innovation, the Systems-of-Innovation approach seeks to identify relations between actors and institutions within the innovation (adoption) system that contribute to innovation uptake or inhibit it. During 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 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 interrelations on the basis of infrastructure requirements, hard (laws and regulations) and soft (values and social behaviour) institutions, weak and strong networks (actors which are loosely or strongly interrelated by choice), capabilities (knowhow, competences, financing capability) but also with respect to factors exhibiting external influence on the innovation system, such as market demand and competition. 'Actors' refers to 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 analyze the failed cases. It allows identifying the reasons behind the lesser outcome or the stage failure of any innovation. This knowledge permits to create the best conditions within the system to secure successful adoption.

The present analysis, after assessing the type and stage of innovation, benefits from the large number of cases (75) in the project sample, most of which have been successful and are financed by the innovation champion. This allows (1) the contextual assessment of actors involved and the 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 and that the number of actors involved increases as the innovation level tends to go 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 to 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 that the first hypothesis cannot "explain" the observed outcomes puts additional weight on the significance of the other three hypotheses, all of which are fully embedded in the Systems-of-Innovation approach. All three were proven valid. In-depth analysis of exceptions highlighted the impact of "market demand" and "port competition" and, most importantly of all, "innovation competition". The latter also causes a lock-in effect and deserves further research, as do the effects innovation systems have on each other.

The present sample of cases did not allow us to study how actors' relations (weak and strong networks) impact on innovation uptake. Hence, this also remains a topic for further investigation and research.

Finally, the innovation promoter / champion was once again found to be crucial to overriding potential setbacks (see hypothesis 4). More specifically, the promoter was found to be better positioned in this respect if they were also the major beneficiary. Further research is however also required in relation to this topic, which special focus on failed efforts to implement innovation.

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 of a modular nature ▪ 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 connected with the port (municipalities and regulators)
Monitoring Innovation Vehicles & Cargo	6	▪ Involvement of a 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 available in-house ▪ External financial support in only 13 out of 75 cases Result: Inconclusive	▪ Number of incremental innovations in the sample: ▪ Relatively low investment ▪ Need to minimize the sharing of financial gains ▪ Privately initiated innovations may wish to avoid lending transaction costs ▪ Risk-averse nature of lenders
2	If all actors in the stakeholder network hold a positive attitude, the innovation is adopted	Confirmed by 44 out of 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 out of 15 cases fitting the criteria	▪ Not all necessary stakeholders were involved
4	The strength of the Innovation Champion will override internal opposition.	Confirmed by 7 out of 8 cases fitting the criteria	▪ Innovation competition (technology mismatch)

Towards CO.Innovation?

Thanks to the use of multiple methods and sources of data collection (in-depth and focus (group) interviews), we were able to check for trends in port-related innovation.

First, the study indicates that the next step in the innovation process will see a shift from a 'profit' to a 'profit and planet' orientation, so that the focus will extend beyond CO_2-emissions reduction in logistics operations and the like. Alongside the environmental perspective, the vision of lean will also gain importance. In future strategic and operational decisions, the integration of leanness considerations in port-related innovation will induce benefits along the maritime supply chain.

Secondly, with respect to IT applications, stakeholders find themselves in a lock-in situation. In previous decades, there was a general interest in developing stand-alone IT systems. Such systems are often incompatible with IT applications of other stakeholders. However, new IT applications will make it possible to move innovation forward faster. To this end, the concept of open innovation, which is already adopted in many other sectors of industry, must be fully embraced in the maritime supply chain. Inevitably, integrating such systems carries a price tag.

Case analysis already suggests that there are benefits and costs for every stakeholder. However, the benefits are not always readily visible, often resulting in a low willingness to pay. At the same time, concern about the cost elements definitely plays in a sector where margins are narrow. Hence, from a game-theoretical perspective, there is no willingness to co-operate (comparable with co-operation between ports). This is easily explained by formalizing the cost and benefits of adopting an IT application in a payoff matrix. The choice is simple: either to continue with the own IT system or to integrate systems. Unlike the innovation champion (e.g. trucking company, carrier…), the follower faces an entry cost that outweighs the benefits, and consequently the game stops. This may also be the driver behind observed support for imitation (Roumboutsos, 2015). The innovation initiative fails[1] or ends in endless discussions about data (ownership, availability, accessibility and modifiable). Opposed to that, if the cost is lower than the benefit or if everyone is in it from the start (cf. openness and trust), an innovative concept is likely to achieve greater success.

The literature on this subject tends to be general rather than dealing specifically with a particular context, such as the maritime supply chain. While plenty of theoretical studies have been carried out into the notion of open innovation, the empirical evidence is rather limited. In the current research, there were too few successful cases to distinguish meaningfully between open and closed innovation approaches (Vanelslander et al., 2015). Hence, future research will need to outline a framework that is conducive to successful open innovation. In this context, the framework proposed by Paasi et al. (2012) already addresses the questions of appropriate forms of collaboration as well as knowledge

[1] Examples of innovation projects in inland shipping that do not evolve beyond the pilot phase are BIVAS (BE), a virtual marketplace for barge operators and shippers, and Bargecloud (NL), a virtual marketplace for multimodal container transport. Alternatively in such cases, one can wait for new technology (e.g. cloud applications) or legislation/intervention. Here, there might be a role for government.

management and data sharing during and after collaboration. Relying on two variables (i.e. partner variety and innovation funnel openness), Lazzarotti and Mazini (2014) identified four basic types of collaborators: closed innovators, specialized innovators, open innovators and integrated collaborators. Collaboration in the maritime supply chain should evolve towards the latter type. 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 but not least, actor co-operation also emerges as an important trend. In the present research and context, initial attempts at working with an upstream and downstream stakeholder often failed. Just a few were subsequently successful, as confirmed in the SIA analysis, but only in a closed innovation approach. Hence, co-innovation is expected to be the most important challenge for the port industry in the decades ahead. Co-innovation is a new form of innovation whereby the various stakeholders jointly acquire new expertise and create opportunities in the supply chain for new partnerships. In the long term, this will lead to a balance between costs and profits as well as a greater competitive advantage. CO.Innovation should not be seen as an end in itself!

Future research

In the next stage of research, success and failure of innovation needs to be studied from a supply chain perspective. The analysis could focus on identifying (additional) competitive advantages in supply chain cooperation and on how innovation might play a role in this respect. This will require a tool to measure the value of innovations or improvements.

To measure the degree of innovation, indicators of how well the port performs in terms of overall innovation level, both in time and in comparison to other ports, are to be combined into a single composite indicator. In addition, individual indicators are to be compiled into an index reflecting innovation developments with respect to profit, people and planet. Future research will focus on collecting data for such indicators.

As regards future innovation, perhaps it might be interesting to identify opportunities for new port-related developments. This would require an adequate degree of insight in the 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 Technological 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 hybrid
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: Industries 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)
Terminal operators	DP World (BE), APMT (IT), AET (BE),Terminal Bruzzone (IT), Jurong Port (SG), PSA (SG)
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 
Minimizing cost	Reducing CO_2	Offering new employment opportunities
Optimizing operations	Reducing air pollutants	Retaining human capital
Gainingmarket share	Minimizing impact of activity on landscape (or proximity territory)	Improving relations with local communities
Obtaining first mover advantage	Reducing noise	Reducing number of accidents
Avoiding depletion of resources	Reducing congestion	Reducing fraud
Impacting positively on competitiveness	Reducing water/soil pollution	Improving the efficiency of security requirements
Growing (marketing)	Improving management of waste	Complying with social and labour regulation
Generating employment (substitution of labour with capital)	Recycling	Complying with safety regulation
Using resources efficiently (equipment, land, etc.)	Integrating other developments in the field of sustainability	
Differenting from competitors	Complying with environmental regulation	
Increasing scale of operations		
Improving energy efficiency		
Integrating with other actors		
Offering larger and equitable access to service		
Encouraging other investments		
Facilitating 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	Failures in the prevailing regulatory and legal frameworks to support the development of a new application.	Regulatory and legal frameworks governing the specific innovation	Legal and regulatory framework and standards in general influencing uptake
Soft Institutions	Failures in social institutions such as political culture and social values that impede the uptake of the innovation.	Political culture, cultural values, social aspects, economic influence, standards imposed by stakeholder or other groups.	As collective understanding 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. Also 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 a view to 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 can occur when actors are too close so that they miss out on external developments.	Actor was involved in the development process. Negative scale indicates a negative involvement towards the innovation project, while positive scale indicates a positive involvement. The values indicate the strength of the relationship. Example: "-3" means the actor was involved, had a strong connection with the project, but impeded the innovation process; "0" means the actor was involved but had no influence on the process; "3" means the actor was closely involved in the project and accelerated 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 ones, may lack the capabilities to learn quickly and effectively and hence may be locked into existing technologies/patterns and unable to jump to new technologies/business patterns. By extension, this may include financial capability.	Capabilities contributed by each actor: personnel; funding; investment; time and/or knowledge.	Ibid.
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.	Reaching a dead-end in a certain phase of the innovation process. Questions: which actors experienced lock-in effect? How did this affect 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 a drive for further efficiency in order to maintain or improve market position.	Market and which actor is demanding for the innovation	Ibid.
Competition (innovation)	Innovation is adopted to address certain aspects of operational efficiency. There may be competing innovations. This is also related to lock-in effects.	Competition from comparable innovations.	Ibid.
Competition (Port)	The adoption of innovation relies on the cooperation of many actors. Intra- and inter-port competition may create restrictions.	Competition from other ports.	Ibid.

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.