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<td>Responsible Innovation as a Driver of Port Development: the Rotterdam Port Maasvlakte 2 and the Dalian Port Dayao Bay Extension Projects</td>
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Responsible Innovation as a Driver of Port Development: the Rotterdam Port Maasvlakte 2 and the Dalian Port Dayao Bay Extension Projects

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Abstract
In view of technological, economic, environmental and social challenges, world ports are searching for new and creative technological and institutional approaches of innovation, development and operation. Generally, two search strategies for a new Sustainable Development course can be distinguished: an ecologically oriented approach and an approach in which both ecological and social aspects are considered. Rotterdam Port and Dalian Port are involved in new sustainable port extension projects and their Maasvlakte 2 and Port Dayao Bay projects exemplify both approaches. This paper discusses these cases from the perspective of Responsible Innovation. This is a new and promising field of scientific activity focussed on the design of an innovation strategy, based on an analysis of the moral values involved in technological and institutional innovation and development, with the aim of balancing and reconciling diverging values in these processes. The paper outlines and specifies Responsible Port Innovation, introducing the outset of a methodological and procedural step-by-step plan for the implementation and evaluation of (responsible) innovations. This plan or roadmap will be used as a guideline for the analysis and evaluation of the two case-studies. The intention is, on the one hand, to assess both projects and give suggestions for improvement, and, on the other hand, to learn from these projects how Responsible Innovation could become a driver of port development.

Key words: Sustainable Port Development, Maasvlakte 2 project, Dayao Bay project, Responsible Port Innovation, Value Management, Methodological and Procedural step-by-step plan.
1 Introduction

The “northern route” is no dream anymore: 10 September 2013 a Chinese ship, the Young Sheng, arrived in the Port of Rotterdam, crossing the Bering Strait, the East Siberian Sea, the Laptev Sea and the Barents Sea, the last one named after an older, Dutch attempt to discover this route. The ship brought two new cranes for the new APMT terminals at Maasvlakte 2. It left the Port of Dalian on 8 August and by taking this route (of 4500 km) it saved over two weeks, compared to the traditional southern route through the Suez Canal. It was not the first ship to do this and the number of ships to follow is expected to be limited the coming ten years because of the ice, but it nevertheless marks a turning point in sailing, though it may be considered a dubious advantage in view of present climate change.

Both ports are taking at least responsibility for their operations and are involved in sustainability initiatives. The Maasvlakte 2 project is explicitly development as a “sustainable port” (Port of Rotterdam, 2014). Dalian Port also has environmental ambitions, which it shows in its Dayao Bay Port project (Green Port Dalian, 2013). These efforts are relevant and significant to port development in general.

Technological, economic, environmental and social developments challenge world port cities. Global trade increases, especially because of strongly developing new players like China, India, Brazil and other emerging economies. Consequently, ports have to handle increasing cargo volumes and expand their capacities. Concurrently, container ships are becoming bigger and bigger, super container ships now requiring depths of 20m (see e.g. Taneja, 2013 and Pettit & Beresford, 2009). In addition, sustainability issues involving climate change (causing sea level rise and changing river discharges), air and water pollution as well as growing pressure on scarce resources, beside rapid urbanization issues (especially in developing and newly emerging economies), require more and more attention. These challenges have to be addressed in a situation in which, on the one hand, trends in global trade and environmental regulations are highly uncertain (Taneja et al., 2012; Taneja, 2013), while, on the other hand, decision and policy-making arena’s involve more and more (critical) stakeholders, especially citizens.

Consequently, port development projects, how necessary they are, also raise public concerns and resistance, for example in the north of Australia close to the Great Barrier Reef (Fight for the reef, 2014), the confrontation between local fishermen and big companies in relation to the development of Shatian Port, Guangzhou in China (He & Ravesteijn, 2014) and, in the Netherlands, the proposal to dismantle the village of Moerdijk (NOS, 2014).

Contested Innovations gave rise to the emergence of a new field of academic activity: Responsible Innovation, which aims at dealing with diverging, competing and sometimes conflicting values, like safety, sustainability, security, transparency, accountability and privacy in innovation and development trajectories, replacing technology and economy as drivers by a more comprehensive propelling force. Responsible Innovation has been conceptually and theoretically worked out into an approach and framework for analysing and evaluating new technologies and other innovations (Owen et al., 2013). It has also been initiated as a strategy for innovation and research (European commission, 2013). This paper continues and specifies these efforts, following up with the beginnings of a practical methodological and procedural step-by-step plan with appropriate methods at every step, for research-based responsible innovations and, by implication, for evaluating innovations from...
a Responsible Innovation viewpoint. Instead of earlier conceptual and theoretical reflections, it aims to learn from practical examples, in this case port extension projects in Dalian and Rotterdam.

In view of all challenges, more and more port cities across the world seem to consider a reorientation and green and sustainable port development projects are being carried out all over the world (see e.g. Cerceau et al., forthcoming). Two somewhat different directions are visible in this:

1. Ecologically sound port development projects, especially eco-port. Such endeavours build on the experience with eco-cities, eco-industrial parks and, to a lesser extent, knowledge cities, water-cities and future-proof delta-cities in general (see e.g. Joss et al., 2013; Newman & Jennings, 2008; Vernay et al., 2010). Such projects are especially implemented in China, where ports are booming, as are trade and the economy in general. As a consequence, eco-city construction has become an influential urban development strategy in China (see e.g. De Jong et al., 2013) and, in its wake, eco-ports are being developed, encouraged and urged by national government policies (Fifth Session, 2013a, b).

2. Socially and ecologically sustainable port projects, which consider social aspects like the integration of ports and the liveability of port cities, beside ecological aspects. Usually, such efforts are based on a more comprehensive, though often flexible concept of Sustainable Development (see e.g. Koppies & Stevens, 2008; cf. Ligteringen & Vellinga, 2012; Taneja et al., 2012; Taneja, 2013).

The Rotterdam Port Maaslakte 2 and the Dalian Port Dayao Bay expansion projects exemplify these two directions respectively (see Green Port Dalian, 2013 and Barker, 2010 respectively; see for other examples, of eco-port: Port of Qingdao, 2002; De Vos & Wang, 2012; Deng et al., 2013, and of sustainable ports: ESPO, 2010, 2012). This paper investigates these projects and discusses them from the perspective of Responsible Port Innovation: what can we learn? How could Responsible Innovation become the new driving force of port development, replacing the currently only technological and economic drivers? This paper also investigates how Responsible Innovation could support these and similar sustainability efforts.

First, we will introduce Responsible Port Innovation and formulate a methodological and procedural step-by-step plan. Consequently, the two cases will be presented and analysed. In the concluding section, we will discuss these projects from the perspective of Responsible Innovation.

2 Responsible Port Innovation

Responsible Innovation can be described as innovation co-shaped by all actors involved (initiators or “internal” stakeholders and social or economic actors or “external stakeholders”) on the basis of data on impacts and options, evaluated and balanced in terms of ethical values (European Commission, 2013). It has come up in a situation in which new technologies and innovations provoke serious concerns and public debate. Cases in point are nanotechnology (Simakova & Coenen, 2013), geoengineering (Parkhill et al., 2013) and Carbon Capture and Storage (European Commission, 2013). Ultimate causes are value conflicts, e.g. between efficiency and privacy and between environmental and safety concerns. An example in which diverging economic, social and environmental aims have been adequately served at the same time, is the successful development and adoption of green energy technologies in some European countries (European Commission, 2013).
Responsible Innovation follows upon Sustainable Development, though it especially addresses the dilemmas which trouble the latter concept (Mulder et al., 2011). It builds on Social Constructivist Design (Bijker et al., 1987) and Constructive Technology Assessment (Schot & Rip, 1996), which emerged in the field of Science and Technology Studies (Jasanoff et al., 1995). It differs from these approaches by its roots in ethical theory and its focus on moral values.

Responsible Innovation is a philosophical-ethical approach (Owen, 2013), but in its application it includes the mobilization of a social support base (European Commission, 2013). It can be understood as a research-based innovation strategy focussed on analysing, assessing and balancing normative judgements in the whole innovation chain on the basis of a combination of the input of experts and other stakeholders. Responsible Innovation raises the questions which fundamental values are involved in an innovation – or broader in the analysis and tackling of a socio-technological problem – and how diverging, competing or even conflicting values could be balanced and reconciled. Responsible Innovation can also be used for evaluative purposes, to determine whether an innovation is responsible or not and how improvements might be possible.

Various methods have been put forward to cope with the necessary balancing and bridging efforts, including (Social) Cost-Benefit Analysis, Multi-Criteria Analysis (trade-offs), logic and ethical theories (“reasoning”), considering thresholds or boundary conditions (borders that should not be crossed, e.g. as determined in law and regulation) and Value-Sensitive Design in the sense of creating a win-win situation (Van de Poel & Royakkers, 2011). These methods are mostly design and expert-oriented, though social embeddedness and stakeholders are considered to be essential in Responsible Innovation, which brings in methods like Actor Analysis (Enserink et al., 2010), Q-Methodology (Cuppen, 2010), Back-casting (Quist, 2007) and Process Management (De Bruijn & Ten Heuvelhof, 2008), beside combinations of methods (e.g. Participatory Cost-Benefit Analysis, Sager, 2012).

Responsible Innovation is relevant to port development projects (and infrastructural projects in general), not only because they sometimes occasion public debate and protests, but also because they involve a variety of goals or values, inherent in their public character: the entrepreneurial (or micro-economic) aim and the social (or macro-economic) aim, i.e. a double goal (Grigalunas et al., 2001). Value diversity especially comes forward in sustainable projects (Koppies & Stevens, 2008; see the earlier mentioned examples). It is the mission of Responsible Port Innovation to deal with such diversity, especially preventing and addressing value conflicts (Van den Hoven et al., 2012). Consequently, it can be described as a strategy for research and innovation in port development that considers and reconciles a range of stakeholders’ values, varying from employment, safety, economic growth, participation, liveability to natural values (see Figure 1).
A challenge of Responsible (Port) Innovation is a detailed methodological and procedural step-by-step plan for implementation, which could guide research on behalf of innovation and evaluation as well. Such a roadmap should contain at least the following methods and questions, marking the consecutive steps in an action plan (cf. Ravesteijn & Kroesen, forthcoming):

1. A problem analysis: what is the problem? For whom? Why?
2. A solution analysis: what counts as a good solution?
3. A technology (opportunity) analysis: which technologies are available? Which new developments can be expected?
4. A stakeholder analysis: who is the problem owner? Who is taking the initiative or should do so? Who are the external stakeholders? What are their significance, involvement and influence as well as their interests and values?
5. An integrated impact assessment including safety and security risks as well as economic, environmental and social consequences.
6. A value analysis of the core values at stake, based on both the stakeholder analysis and the impact assessment.
7. Dealing with conflicting values through Cost Benefit Analysis, Value-Sensitive Design or other methods.
8. Feeding the outcomes in the design and development process, e.g. through using methods and insights from Constructive Technology Assessment.
9. Introducing the new technology in collaboration with stakeholders, e.g. by applying methods and experiences from impact assessment research.
Various expert and stakeholder methods are available for addressing these issues, in addition to the ones mentioned above. We will discuss and evaluate the two cases on the basis of this step-by-step plan.

3 The Maasvlakte 2 project, Rotterdam Port

3.1 Introduction
Rotterdam Port is the largest port in Europe and with a 2012 volume of 11.87 million TEUs (twenty-foot equivalent units) number 11 in the Top 50 World Container Ports (World Shipping Council, 2013; Port of Rotterdam, 2014; see also Vellinga 2013b; Pesch & Ravesteijn, 2012, 2013). As Europe’s logistical nerve centre the port facilitates the needs of a hinterland with 40,000,000 consumers. Between 1962 and 2004 it was the world’s busiest port, but this position has been overtaken by Shanghai and Singapore. In 2006 it was the sixth, in 2008 it was the ninth and in 2009 it was the world’s tenth-largest container port. In 2011 Rotterdam Port was the world’s fifth-largest port in terms of annual cargo tonnage. The port covers some 105 square kilometres (41 square miles).

Landlord of the Rotterdam Port (Bowden & De Jong, 2006) is the Rotterdam Port Authority. Originally it was a branch of service of the Rotterdam municipality, but since 2004 it has been an independent company with two shareholders: the municipality of Rotterdam and the Dutch State.

Core values of the Rotterdam Port are: safety, sustainability, accessibility, reputation and the creation of societal value (as constructed by Van der Lei & Ligtvoet 2013; see Figure 2).
Throughout the years, the port authorities have undertaken a series of port extension projects in order to keep up with developments in international trade and shipping technologies, especially the increasing size of the (container) ships. Last in line is the Maasvlakte 2 project (see Figure 3: number 1 is the Maasvlakte 2 project). The Rotterdam Port authority embarked on this project in 2008, after a planning trajectory that goes back to the 1990s. It was the biggest engineering project in the Netherlands after the delta works. The complete port was expected to be operational in 2013, which actually happened.
3.2 Policy backgrounds

Basically, the Rotterdam Port aimed to improve or at least consolidate its position as a world port, but in ways fitting in with existing local, provincial, national and European laws and regulation and acceptable if not supported by the citizens of Rotterdam and the general public (see Havenvisie 2030, Port of Rotterdam 2014; Vellinga, 2013b).

As a “Clinton city”, the city of Rotterdam fights climate change through the Rotterdam Climate Initiative and the Rotterdam Port joins the effort to become “carbon neutral”, or at least to reduce CO2 emissions. It could be considered a case of Corporate Social Responsibility, in which the Port Authority safeguarded the approval, execution and acceptance of the project, while working on its reputation as well, the latter both in business and in sustainability.

3.3 Project description

The Maasvlakte 2 project is part of the bigger Rotterdam Mainport Development project, which embraces two other (sub-)projects, aimed at further developing the Existing Rotterdam Area (a series of projects to make better use of the existing port area and to improve the quality of the living environment), carried out by the Municipality of Rotterdam, and the creation of 750 hectares of Nature and Recreation area (on Midden-IJsselmonde and to the north of Rotterdam), in which the Province of South Holland takes the lead (Vellinga 2013a; Pesch & Ravesteijn, 2012, 2013).

The port project itself consists of the construction of new port area and the associated environmental compensation for damage to protected nature. One activity is the Land Reclamation (carried out by the involved Project Organization, a consortium of companies: PUMA), embracing approximately 2000 hectares, behind a 4 km dike. Approximately 1000 hectares will be used by port
related industries. The accompanying Compensation of Nature project has two parts, involving Dunes Delfland and Sea Bed Protection Area, carried out by several ministries.

Container terminal operators APM Terminals and Rotterdam World Gateway (RWG) began construction of their terminals in 2012. RWG is the main competitor for European Container Terminals (ECT), currently the biggest terminal operator in Rotterdam. RWG’s terminal will include a 20-meter deep dock and its own railroad station, and it will be capable of handling 2.35 million containers annually.

### 3.4 Project goals

The goals of the Maasvlakte 2 project were (and are) ambitious: to continue and safeguard the position of Rotterdam as a world port and to improve the liveability of the region, explicitly referred to as the “double goal”. To effectuate this ambition, the Maasvlakte 2 project contained the following sustainability aspects (Port of Rotterdam, 2014; see also Vellinga, 2013a):

- **Design**: the selected “cut-through variant” (the new port is connected with the sea through the old port, not directly) is compact, fits into the coastline and is safe
- **Construction**: reuse of blocks and quarry stone & smart sand extraction (deep holes, instead of over a broad surface)
- **Layout**: efficient land use
- **Operation**: sustainable industry & distribution, tendering container terminals (tenders were judged on sustainability, counting for 20%)
- **Energy & process industry** (Industrial Ecology-like connections)
- **Transport**: modal shift from road to railway and waterway, especially the latter
- **Dialogue**, with NGO's

In addition, the Rotterdam Port Authority advances flexibility for sustainability reasons through temporal and multifunctional use of provisions (Ros, Taneja & Vellinga, 2012). With all of this, Maasvlakte 2 should become the most sustainable port area in the world.

### 3.5 Management of values

The question, which is especially interesting in the context of this paper, is how the Rotterdam Port Authority dealt with diverging, competing and conflicting values. Of course, they used the method of “considering thresholds or boundary conditions”, to meet all legal demands, not in the last place from a much requiring Europe. The cut-through variant can be considered a case of Values-Sensitive Design, with a choice in favour of the design which was not expected to disturb or deteriorate protected nature values (see Figure 4).
Multi-criteria Analysis was applied in the case of the tender for terminal companies, where bids were assessed on sustainability for 20% (see Hertzberger, 2010). To this purpose, APM Terminals plans to use electrically driven Lift-Automated Guided Vehicles, which strongly reduce CO2 emissions in comparison with the traditional diesel fuelled vehicles. In addition, APM performs its own fight to meet and reconcile different values through smart solutions, including extra-large cranes for productivity reasons, zero tolerance for unsafety and a green office building (APM Terminals, 2014).

Cost-Benefit Analysis has played a major role in all deliberations about the project proposal, on the basis of a multitude of reports (e.g. CPB, NEI & RIVM, 2001; GHR 1998a, b, c; see also Port of Rotterdam, 2014).

Dialogue was clearly used in the contacts with social stakeholders. In 2008, the Quality Control Round Table (Tafel van Borging) was founded by 13 parties, based on a covenant (“Visie en Vertrouwen”, DCMR Milieudienst Rijnmond, 2011) providing a framework for the monitoring and evaluation of the agreements about the Project Mainport Rotterdam. Six government bodies, six NGO’s and the Rotterdam Port Authority Port discuss the progress of the complete project (both Maasvlakte 2, the related nature compensation, other new nature and a series of other liveability projects) and the solution of eventual problems during half-yearly meetings, guided by an independent chairperson (presently, the former minister Sybilla Dekker). (See for stakeholder issues and agreements: Vellinga, 2013a).

Not all NGO’s were in, however, and some environmental organizations remained critical, especially the Dutch branch of Friends of the Earth (Milieudefense). After years of tensions, however, the Rotterdam Port Authority and this NGO made an agreement in 2009, through which the Port prevented legal proceedings to be instituted against it. The Port would see to it that harmful

Figure 4 Maasvlakte 2 cut-through variant
submissions would be 10% less than expected in the environmental impact studies, more than legally obliged, and, in exchange, Friends of the Earth would stop its resistance. In 2011, an elaborated version was presented, which contains a whole range of measures proposed, including the promotion of clean shipping and an exploration of the use of onshore electricity (see Minder schadelijke stoffen door akkoord Milieudefensie en Havenbedrijf, 2013).

4 The Dayao Bay extension project, Dalian Port

4.1 Introduction
The Port of Dalian, lying at the southern tip of Liaodong Peninsula, is the most northern ice-free port in China and number 17 in the Top 50 World Container Ports, in 2012 handling a volume of 8.06 million TEUs (World Shipping Council, 2013). As the largest multi-purpose port in Northeast China and the “trade gateway” to the Pacific, it is serving seaports in North Asia, East Asia and the Pacific Rim (Port of Dalian 1, 2013). It is a port that has experienced a fast growth the past decades, profiting from the opening up of China end 1970s.

The port is owned and managed by the state-owned Dalian Port Company, established in 2005 (Dalian Port Company, 2013). Being a state-owned company, Dalian Port gets supervision as well as financial support from central government branches such as the National Development and Reform Commission (NDRC), the state-owned Assets Supervision and Administration Commission (SASAC), the Ministry of Transportation (MT), the Ministry of Environmental Protection (MEP), as well as their subordinate bureaus in Liaoning Province and Dalian Municipality. More than just a listed company in Hong Kong and Shanghai, taking annual profit as its main goal, Dalian Port is actually implementing the Meta policy for environmental protection (see below), its performance being used as a feedback to local as well as central government. This policy and feedback constitute the initial motive for its eco-port building effort and the driving force in its expansion activities.

The core values of Dalian Port seem to be comparable with those of Rotterdam (Van der Lei & Ligtvoet 2013), albeit with other accents. Economic value creation and safety are central, while eco-greening and public satisfaction are of increasing importance (Green Port Dalian, 2013; Chinese shipping, 2013).

In the course of time, Dalian Port has undertaken a series of extension projects (see Figure 5; Port of Dalian 2, 2013). It has a “one core two wings & one island two bays” policy, with the old port area in the city and the northern Dayao Bay as the core and the coast zones on both sides and up north of the Dalian peninsula as the wings (Wei Liu, 2013), including Changxing Island and Taiping Bay.
4.2 Policy backgrounds
In 2005, top leaders in the Fifth Session of the Sixteenth Central Committee of the Chinese Communist Party clearly demonstrated their concern about the sustainability of China’s development (Fifth Session, 2013a). Turning to an open and competitive economy, it was said that, at the same time, China rapidly consumed its environmental resources. Thereby, for the first time, “building a resource-saving and environment-friendly society”, as a Meta policy, was written into the Five-Year Plan (2006-2010), which is the crucial guideline for mapping strategies of economic development, setting growth targets and launching reforms in China.

The plan also put forward 22 quantitative targets. To be noticed most is that, in the time span from 2006 to 2010, the total discharge of major pollutants of SO2 and CO2 should drop by 10% compared to levels of 2005 (Fifth Session, 2013b). MT especially held a national conference to clear out the future policies in implementing the 2005 strategy. In 2007, the minister of MT raised the widely discussed question of how to transform the growth mode in the transportation industry, which started a change in both transportation industrial policy goals and organizations performance assessment (Li Shenglin, 2013).

According to another regulation in 2009, “Opinions of the State Council on Further Implementing the Strategy of Revitalizing the Old Industrial Bases Including Northeast China”, Dalian Dayao Bay Bonded Zone was acknowledged as the core of the Dalian Northeast Asian International Shipping Hub, and also the node connecting Suifenhe Comprehensive Bonded Zone and Shenyang Bonded Logistics Center, which comprises the premises for bonded logistics and processing industry in the Northeast Region.

Consequently, Dalian Port was offered allegiance for its expansion and its development as an eco-port, guaranteeing its cooperation with the Dalian Municipality under the concept of port-city integration, as well as financial support from statutory actors and loans from banks. The total investment for port expansion was over 10 billion Yuan, which means that eco-port construction is
financially possible. In 2013, the Dalian Port Group announced to invest 1.2 billion Yuan ($196 million) into ecological port development and operations over the next three to five years, to turn the harbour into an advanced, high-tech port with good economic returns, low energy consumption and little pollution (Chinese shipping, 2013). In its port planning and building Changxing Island, Taiping Bay and Dayao Bay Ports definitely have priority. The Group optimistically estimated that the port greening will cover 95% of the total area; the rate of water reuse will reach 55%; and public satisfaction with the environment of the port will be more than 80%.

4.3 Project description
Dayao Bay is one of the eight port zones of Dalian Port and is bordered immediately to the Dalian Economic and Technology Development Zone. The Dayao Port is a new port and it is under construction in various stages since the 1980s, with the fourth phase of construction to be finished in 2014 (Port of Dayao, 2013). The project comprises the building of ten berths in total. The construction of four of them (with a handling capacity of 2.6 million tons per year) started in 1988 and they were operational in 1993. However, in view of realized and expected cargo volumes, there was a pressing need to continue constructing the other six new berths.

4.4 Project goals
Dalian Port’s development goal is to consolidate and strengthen its position as the main port in Northeast China, to officially become the Northeast Asia Shipping Centre and to play a major role in creating this centre, at the same time stimulating the development of port-related industry and the city of Dalian in general. The Dayao Bay project plays a major role in the regional economic development and has attracted a lot of attention from statutory actors at various levels.

The Port is profiling itself as an innovative and green port, with regard to the latter in its planning focusing on:

- Low carbon infrastructure construction, such as ships using onshore electricity and the application of efficient light bulbs.
- Application of low carbon transportation equipment. For example, rubber-tire container gantry cranes using electricity instead of oil as power source.
- Application of clean energy. For example, port vehicles and machines using natural gas instead of oil as fuel (Wei Liu 2013).

In March 2013, the Dalian Port Group signed an agreement with the Dalian Environmental Protection Bureau, namely: “A Corporative Frame on Promoting A Green Port in Dalian”, which set a time table and arranged other practical details for ten projects (Green Port Dalian, 2013). The ten “Eco-green Projects” are:

- Building a port-city integration eco-demonstration zone in Taiping Bay by using a low-carbon environmental rail traffic system.
- Building a low-carbon logistics port by relying on new technologies of energy saving, low costs and green materials.
- Applying technologies of energy substitution such as substituting oil with gas or with electricity, solar and onshore power supply, accomplishing the substitution of oil by gas for
10,000 container trailers, substituting oil by electricity for loading fields and bridges in the port area in 3 years, and using green energy-saving automatic container handling bridges in the newly built port area for a clean operation.

- Adjusting the functional layout and professional running of terminals in order to improve bulk cargo dust control.
- Building a green port transportation system as a way of optimizing port logistics and clean transportation.
- Building professional service terminals targeting circular economic zones.
- Building environmental equipment manufacturing harbour industrial zones to boost the development of the environmental protection industry.
- Optimizing and adjusting liquefied terminal distribution, establishing a spill oil monitoring system and developing an ecological-type chemical port.
- Perfecting the port and terminal environmental risk emergency measures and contingency system.
- Retrofitting the LED road lighting system within the port area, treating small boilers, and conducting eco-greening of the port.

As for the Dayao Bay project, the goals were to accommodate rapidly increasing cargo handling demands through the improvement and expansion of Dalian Port Dayao Bay facilities, to thereby contribute to the economic development of the region, while at the same time improving efficiency and safety as well as considering environmental and liveability aspects (Evaluation Dayao Port, 2013). The first signals are that targets were achieved (ibid.).

4.5 Management of values

How were – and are – different values dealt with in the Dayao Port planning? Conclusive data on the insides of policy and decision-making as well as the design and development of the project are lacking, but a few preliminary observations can be made. The environmental goals and efforts are impressive and where these have been used in the shaping of the project, de facto Value-Sensitive Design is visible. However, it seems obvious that the project has been mainly embarked on in relation to increasing trade volumes and economic development general. A second top priority has been safety of operations. Though social and environmental goals and values were clearly included, it looks as though that happened to the extent that the primary objectives were not endangered, though some Multi-Criteria Analysis seems to have been applied, trading-off economic and social-environmental issues. Dominant method of balancing values has most probably been Cost-Benefit Analysis. That echoes a broader practice (Chen, 2004, 2005; Coto-Millan et al., 2010), though things are changing, in general and in Dalian Port. The public was not involved, though public resistance could make a difference, as appeared from the fact that a chemical industry project (with regard to p-Xylene) was cancelled under pressure of the public opinion (Port of Dalian 2, 2013).

5 Discussion, conclusions and further research

Responsible Innovation is a new and promising approach in addressing social problems through new technology and in dealing with diverging values in particular. Following earlier conceptual and theoretical contributions, this paper has formulated a first methodological and procedural step-by-step plan, which is essential for the successful application of Responsible Innovation. This roadmap
can be used for innovation research and evaluation. In this paper, it is used as a guideline for the analysis and evaluation of two cases: the Rotterdam Port Maasvlakte 2 and the Dalian Port Dayao Bay extension projects, representing two more or less different routes of sustainable development.

To which extent can both cases be considered as examples of Responsible Port Innovation? The port expansion projects of Maasvlakte 2 and Dayao Bay were set up and embarked on from a clear double target perspective, serving both economic and social-environmental values, though explicit in the first mentioned project and implicit in the second. Economics and sustainability were both addressed in building Maasvlakte 2. A good example is APM Terminals, operating and innovating within the frame of their contract with the Rotterdam Port Authority, which aims to realize both economic and social benefits through electrifying its operation. Dalian Port aspires to revolutionize its energy system, in which electricity plays a major part. However, these and other sustainability plans are still largely on the drawing board and at most a promise for the future.

Consequently, the Maasvlakte 2 project also scores better on our Responsible Innovation step-by-step plan, as appears from the overview indicating which points and questions were more or less consciously addressed in the decision-making on both projects in Table 1.
**Table 1 Responsible Innovation in the Maasvlakte 2 and Dayao Bay extension projects**

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<th>Steps</th>
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<td>2 Solution analysis</td>
<td>Yes</td>
<td>Long-term vision based on Technology Forecasting &amp; Back-Casting, Strategic reports, Havenvisie 2030, PoR 2014</td>
<td>Yes</td>
<td>Wei Liu 2013</td>
</tr>
<tr>
<td>3 Technology analysis</td>
<td>Yes</td>
<td>Strategic reports, Havenvisie 2030, PoR 2014</td>
<td>Yes</td>
<td>Wei Liu 2013</td>
</tr>
<tr>
<td>4 Stakeholder analysis</td>
<td>Yes</td>
<td>Project documents, PoR 2014</td>
<td>No data, probably only internal stakeholders</td>
<td></td>
</tr>
<tr>
<td>6 Value analysis</td>
<td>Limited</td>
<td>Van der Lei &amp; Ligtvoet 2013</td>
<td>No data</td>
<td></td>
</tr>
<tr>
<td>7 Dealing with conflicting values</td>
<td>Intuitively, not systematically</td>
<td>Van der Lei &amp; Ligtvoet 2013</td>
<td>Intuitively, not systematically</td>
<td>Changxing Island EIA report 2014</td>
</tr>
<tr>
<td>8 Feeding outcomes in design and development</td>
<td>Yes, in as far as outcomes were present</td>
<td>Cut-through variant &amp; other sustainability aspects, PoR 2014</td>
<td>No data</td>
<td></td>
</tr>
<tr>
<td>9 Introduction with stakeholders</td>
<td>Limited in (re)design &amp; development, full in monitoring</td>
<td>Agreement with Friends of the Earth, PoR 2014, DCMR 2011</td>
<td>Adaptations on the basis of public pressure</td>
<td>Presentation 2013</td>
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</table>

We might conclude that the Maasvlakte 2 extension project meets most requirements of Responsible Innovation, while the Dayao Bay Port project, at best, is on its way to become one. However, both cases also elicit suggestions for improvement as to their continued development and future port development in general.

Responsible Innovation focusses on values and value differences, which results in the need of a value analysis of projects and stakeholder positions (like Van der Lei & Ligtvoet, 2013 did) as well as a search for and reflection on possibilities to abridge oppositions. Various methods for dealing with diverging values have indeed been used in both projects, though not always explicitly. In the Maasvlakte 2 project, design and expert oriented methods were used, including (Social) Cost-Benefit...
Analysis and Value-Sensitive Design, as well as process and stakeholder engagement methods, including Dialogue with NGO’s. Some of these methods may have been used in the Dayao Bay case, especially Value-Sensitive Design (though as in the Maasvlakte 2 project not explicitly) and Cost-Benefit Analysis.

Data showing that “reasoning” on the basis of logic and ethical theories has consciously and systematically played a role in the decision-making as to both projects are lacking. In the Maasvlakte 2 case, it looks as though – in the final analysis – utilitarian considerations (Cost-Benefit Analysis) went together with other ethical considerations, e.g. pertaining Procedural Justice (Dialogue) and Intergenerational Solidarity (Sustainability). In both cases, decision-making might have gained from making value positions and considerations much more explicit, though the question remains: how could “reasoning” on the basis of ethical theories or principles have been applied in the decision-making process? What difference would it have made?

The conclusion seems justified that, in the case of the Maasvlakte 2 project, Responsible Innovation was a driver, not only technologically (e.g. cut-through variant), but also institutionally (Quality Control Round Table) and socially (the dialogue with Friends of the Earth). In this sense it replaced the combination of technology and economics that is today’s dominant driver behind port development. However, is still not technology and economics the major force, with all sustainability and responsibility efforts part of an elaborate and sophisticated Corporate Social Responsibility and reputation management strategy? (Cf. Van de Poel & Royakkers, 2011). There is no conclusive evidence here, but one thing is sure: if in the end, the project would only have been possible using this strategy, and that seems very much to be the case here in view of the public, than the business case and the Responsible Innovation case would have coalesced!

The Dayao Bay extension project, however, also serves multiple targets, though the driver is rather government policies than Responsible Innovation in itself. Also, though the data collected are far from sufficient, economic goals seem to be decisive. Nevertheless, the environmental initiatives have been impressive and improvement is in the air, in which the increasingly concerned and involved public may play a major part (see Alagappa, 2004).

In the Maasvlakte 2 project, stakeholders manifested themselves – solicited and unsolicited – in several stages (planning stage, monitoring, innovation) and at different levels (port management, social environment). Stakeholders are in a position to co-manage in the Quality Control Round Table, while they also directly negotiated with the Rotterdam Port and not without success. Consequently, it might be concluded that the Maasvlakte 2 project de facto has been – and is still – run as a process, though a conscious and systematic use of Process Management right from the start could have avoided events like the clash with Friends of the Earth. Involvement of stakeholders was less clear in the Dayao Bay case, though even here a project was cancelled following upon public action. It goes without saying that also here Process Management could have made – and can still make – a difference.

In addition, the Maasvlakte 2 project has some other open ends where Responsible Innovation could be helpful. A systematic approach in addressing specific sustainability issues has lacked. In the tender for terminal companies, sustainability counted for 20% in the evaluation of the bids. Why 20%? How
has this criterion been used precisely? With regard to Cost-Benefit Analysis: what was precisely the business case of Maasvlakte 2? As concerns the dialogue with the environmental NGO’s the question (for the future) is how this will result in clean port operations and shipping. The general research question here might be: How to make a decision model to cope with diverging values?

What can we learn from these cases? Both clearly show the interaction of the technical, institutional and social facets of port development, as well as the broader significance of port innovation for the development of city, region, and ultimately the whole country, China or the Netherlands. Responsible Innovation is thus not only a multi-faceted approach, but a multi-level approach as well!

Both projects also show the crucial part of the public. Port development and other large technological projects involve a great many economic and social stakeholders. Also, these stakeholders might change their opinion on the basis of new information and insight, while new stakeholders might arise or other relevant developments might take place during the long duration of such a project. Consequently, involving and managing stakeholders deserves special interest in Responsible Innovation, during the execution of a project and the innovation trajectory as a whole. A range of stakeholder methods could be employed in supporting and shaping socio-technological development innovation and development processes, including Back-casting, Q-methodology and Process Management. These methods are indispensable in the Responsible Innovation toolkit, enabling a broad set of stakeholders and their values to be explicitly and systematically addressed.

The Rotterdam Port Authority wishes to transfer its approach of sustainable port building to other locations in the world, preferably with some participation (Port of Rotterdam, 2014). Is that possible? Could Responsible Port Innovation be an internationally attractive approach and business case? Could Responsible Port Innovation replace economy and technology as main propelling force? And if Dalian Port realizes its ambitious environmental goals and will involve stakeholders as well, would that be transferable in China? And elsewhere? The answers, of course, require further research, however, first and foremost in ports. As appears from the two cases, ports are not only spearheads in globalization, they are also laboratories and hot spots of sustainability and responsibility, from which academics can learn a lot.
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