ECO-INNOVATION IN THE DUTCH INLAND SHIPPING SECTOR

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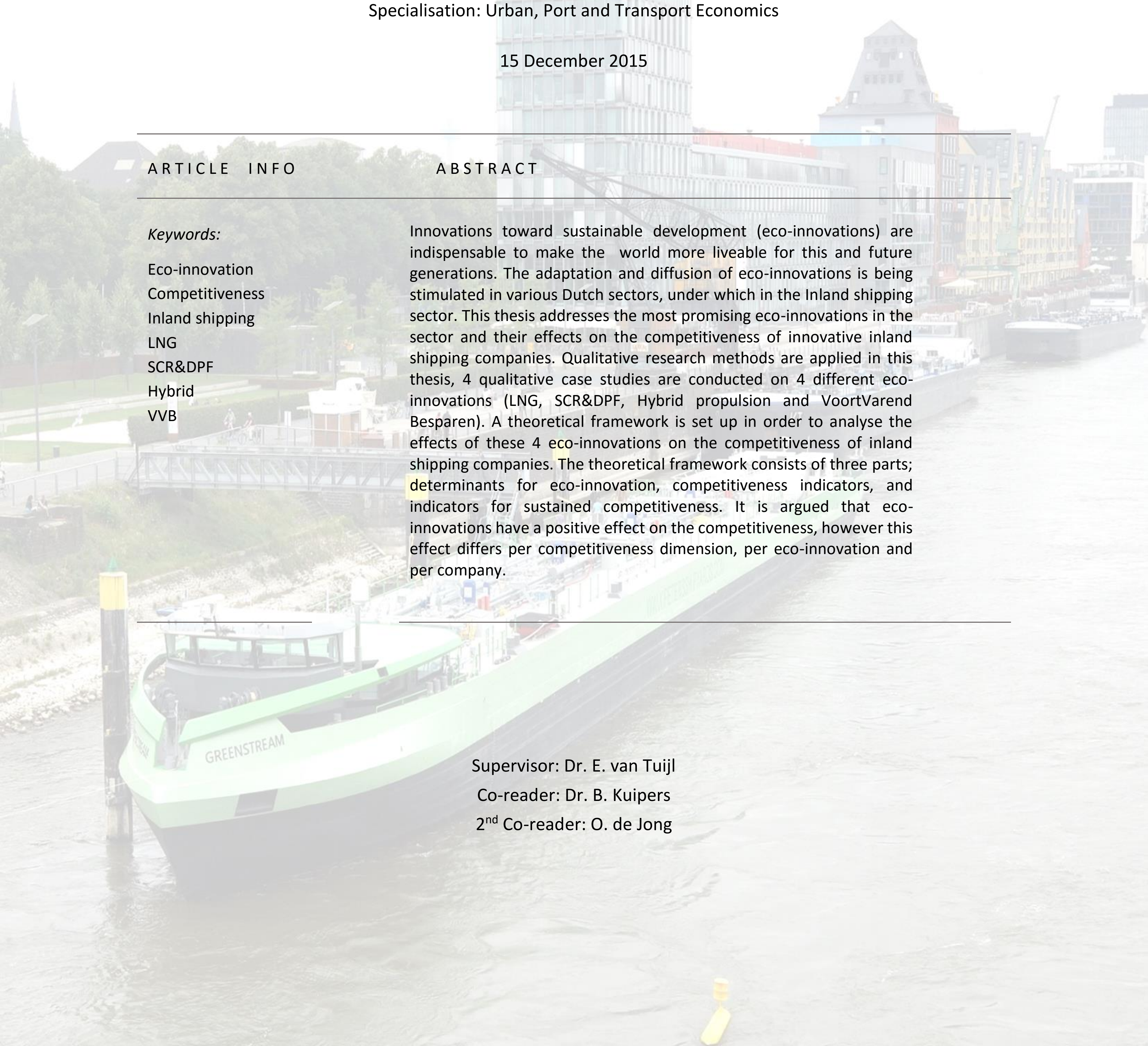

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ABSTRACT

Innovations toward sustainable development (eco-innovations) are indispensable to make the world more liveable for this and future generations. The adaptation and diffusion of eco-innovations is being stimulated in various Dutch sectors, under which in the Inland shipping sector. This thesis addresses the most promising eco-innovations in the sector and their effects on the competitiveness of innovative inland shipping companies. Qualitative research methods are applied in this thesis, 4 qualitative case studies are conducted on 4 different eco-innovations (LNG, SCR&DPF, Hybrid propulsion and VoortVarend Besparen). A theoretical framework is set up in order to analyse the effects of these 4 eco-innovations on the competitiveness of inland shipping companies. The theoretical framework consists of three parts; determinants for eco-innovation, competitiveness indicators, and indicators for sustained competitiveness. It is argued that eco-innovations have a positive effect on the competitiveness, however this effect differs per competitiveness dimension, per eco-innovation and per company.

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Co-reader: Dr. B. Kuipers

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Preface

I am hereby proud to present you my master thesis "Eco-innovation in the Dutch Inland Shipping Sector". The completion of this thesis marks the end of my master program Economics and Business, specialisation in Urban, Port & Transport Economics. First of all, I would like to express my kind gratitude to my supervisor Dr. E. van Tuijl for his excellent supervision. His great comments and suggestions have contributed a lot to the successful completion of my thesis. Second, I also wish to thank my interview partners and colleagues at the EICB. Without their valuable contribution and support it would have been impossible to successfully complete this thesis. Third, I would like to thank Dr. B. Kuipers and O. de Jong for their role as co-reader. Fourth, I would like to thank my family and friends, and in particular my parents. They have supported me throughout my lifetime and without their support I would have been nowhere.

Any errors or omissions in this thesis are my sole responsibility and should not be attributed to any of the excellent people mentioned above.

"The enterprise that does not innovate inevitably ages and declines. And in a period of rapid change such as the present… the decline will be fast."

-Peter F. Ducker

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1. Introduction

1.1 Background

In recent decades the global economy faced a significant expansion and it will continue to expand in coming decades. However, the other side of the coin shows worldwide growing environmental concerns. Global economic expansion contributes to negative externalities like emissions which in turn contribute to climate change and air pollution, forming a significant threat to the earth and species living on it (OECD, 2009). The transport sector accounts for a large share of these emissions and this receives a lot of attention in society. The European Union and the Dutch government are determined to lower the level of emissions caused by the transport sector and are accordingly taking measures to realize it. These measures includes among others more stringent emission standards, supporting sustainable innovations with subsidies and fiscal measures in favour of sustainable transport (SER, 2014). Sustainable development is therefore currently a driving force with significant impact on the organisation of logistics. It is a hot-topic in the Dutch transportation and logistics industry and its importance will only increase on the long term.

Within this industry there are a lot of initiatives to bring sustainable development to the attention of the inland shipping sector. Partly because of the lagging developments in environmental performance as compared to road transport (TotaalTrans, 2013). The gap in terms of emissions between inland shipping and road transport is narrowing, which is in favour of road transport. An important reason for this is the relatively longer technical and economic lifetime of ship engines as compared to truck engines. Therefore, many ships currently run on relatively old and polluting engines. Beside it, because of its limited size the market for inland ship engines is not able to match the technological developments in the market for truck engines. However, new emission standards will be implemented in the near future and more than 50% of the fleet should be renewed in order to meet the new standards (Rijkswaterstaat, 2013).

These developments threaten the uncontested position of the inland shipping sector in the field of emissions. This mainly concerns the pollutant emission of nitrogen oxides (NO_x) and particulate matters (PM). Air pollution created by abovementioned emissions is a danger for asthma patients and it worsens heart diseases and breathing complaints, leading to premature deaths among European residents (Panteia, 2013).

This is a major issue for the Netherlands, given the fact that the Netherlands has the largest inland shipping fleet in Europe and while this fleet is strongly present in densely populated places like the city of Rotterdam (BVB, 2013). Consequently, eco-innovations, or also named environmental innovations, are on the rise in the Dutch inland shipping sector. These are innovations which contribute to a decrease of environmental burdens and consequently improve the environmental performance of the inland shipping sector (Rennings, 1999). Eco-innovations contribute to lower levels of CO_2 and pollutant emissions and consequently counteract climate change and improve air quality. This contributes in turn to a better world to live in, both for current and future generations, and consequently emphasizes the importance of this subject from a societal point of perspective.

1.2 Problem definition

Next to the effects on the environmental performance, eco-innovations may also have an impact on the competitiveness of eco-innovative inland shipping companies. However, no academic research is done on whether eco-innovation affects the competitiveness of innovative inland shipping companies. The existing literature on eco-innovation is mainly related to the secondary sector of the economy and only limited literature is available on the tertiary sector which the transportation sector belongs to (del Val Segarra-Oña & Peiró-Signes, 2013). The limited available literature on eco-innovations in the transportation sector puts the focus mainly on public transport or road freight transport.

Moreover, as compared to other modalities there is in general only limited academic literature available on inland shipping. It is therefore important from a scientific point of view to fill the gap in academic literature by doing research on the link between eco-innovations and competitiveness of eco-innovative inland shipping companies. The reason for this lacking research could be the limited market share of inland shipping in global and European freight transportation as compared to other modalities (Pastori, 2015). Nevertheless, the market share of inland shipping in total freight transportation is relatively high in the Netherlands as compared to other countries (Pastori, 2015). The inland shipping sector is therefore much more relevant to the Netherlands as compared to other countries, both from a social and economic point of view.

Regarding the relationship between the environmental performance and competitiveness, two popular views can be found in the academic literature; the 'traditionalist' view and the 'revisionist' view (Carrillo-Hermosilla et al. 2009). According to the traditionalist view there is a trade-off between improving the environmental performance and improving the competitiveness. This view may apply particularly to pollution intensive industries like the energy industry (Filbeck & Gorman, 2004). On the other hand, the 'revisionist' view argues that there is rather a positive relationship between environmental performance and competitiveness. The 'Porter hypothesis' is a famous example of this view. Porter and van der Linde (1995) argue that environmental regulations push organizations to improve their environmental performance which in turn improves the competitiveness of the organization, indicating a positive relationship between environmental performance and competitiveness.[1]

1.3 Research question

The question is; which of abovementioned views apply to the case of eco-innovative inland shipping companies? Are these eco-innovations an inevitable burden caused by the tightening regulatory standards or do they also positively contribute to the competitiveness of innovative inland shipping companies?

Consequently, the central research question is:

- To what extent affects eco-innovation in the Dutch inland shipping sector the competitiveness of inland shipping companies?

The following sub-questions are formulated in order to answer the central research question:

1. What is eco-innovation, and why is it relevant?
2. How can competitive advantages be obtained?
3. How does eco-innovation affect a company's competitiveness?
4. What is the current state of eco-innovations in the inland shipping sector?
5. What are the experiences of eco-innovative inland shipping companies concerning their competitiveness?

[1] The emergence of the cleantech-sector in the German industrial heartland, the Ruhr area, is an important development in this regard. Stringent environmental regulations pushed firms in the Ruhr area to improve their environmental performance. The region succeeded in improving the environmental performance by significantly developing clean technologies. Moreover, the Ruhr area became the centre for clean technologies in Germany, creating many job opportunities and exporting serious amounts of clean technologies. This enabled companies in the Ruhr area and the Ruhr area as an industrial cluster to regain its competitiveness in Europe (Hospers, 2004).

1.4 Research approach

Qualitative research will be the main approach of this thesis, consisting of literature reviews and interviews with relevant stakeholders. In order to answer the first sub-question, existing scientific literature on eco-innovation will be discussed. The subject of eco-innovation lies in-between the economic sub-fields of environmental economics and innovation economics. Therefore, academic articles both in the field of environmental economics and innovation economics will be used. For the second sub-question the focus will be on existing theories on competitive advantage. This is a central theme of the academic field of strategic management and consequently articles in this field will be used. The third sub-question will be answered by combining the answers given on the first and second sub questions, and through analysing existing literature on the link between eco-innovation and competitiveness. The literature review provides thus answers to the first three sub-questions, making up the first part of the research. This first part provides the necessary building blocks for the theoretical framework which will be built and used for the empirical part (chapter 4) of the research. Interviews and discussions with relevant stakeholders (e.g. EICB) and eco-innovative inland shipping companies (e.g. Danser Group), sector related reports and articles will function as input for the empirical part of the research and thereby help to answer the remaining sub-questions.

1.5 Scope of research

The analysis is limited to the Netherlands mainly due to the fact that the Dutch inland shipping sector is the largest and most significant one in Europe. As a result, eco-innovations are relatively more present in the Dutch inland shipping sector as compared to other countries which also have a significant inland shipping sector, like Germany and Belgium. This makes the Dutch inland shipping sector a more interesting sector to analyse.

The focus of this research lies on the following eco-innovations which are present in the Dutch inland shipping sector:

- LNG as alternative fuel
- Emission after-treatment of diesel engines (SCR&DPF installation)
- Right-sizing and hybrid propulsion
- Energy efficient navigation (VoortVarend Besparen)

According to the EU-funded project 'Promoting Innovation in the Inland Waterways Transport Sector' (PROMINENT) these are the best available greening technologies and concepts ready for mass introduction in the inland shipping sector.

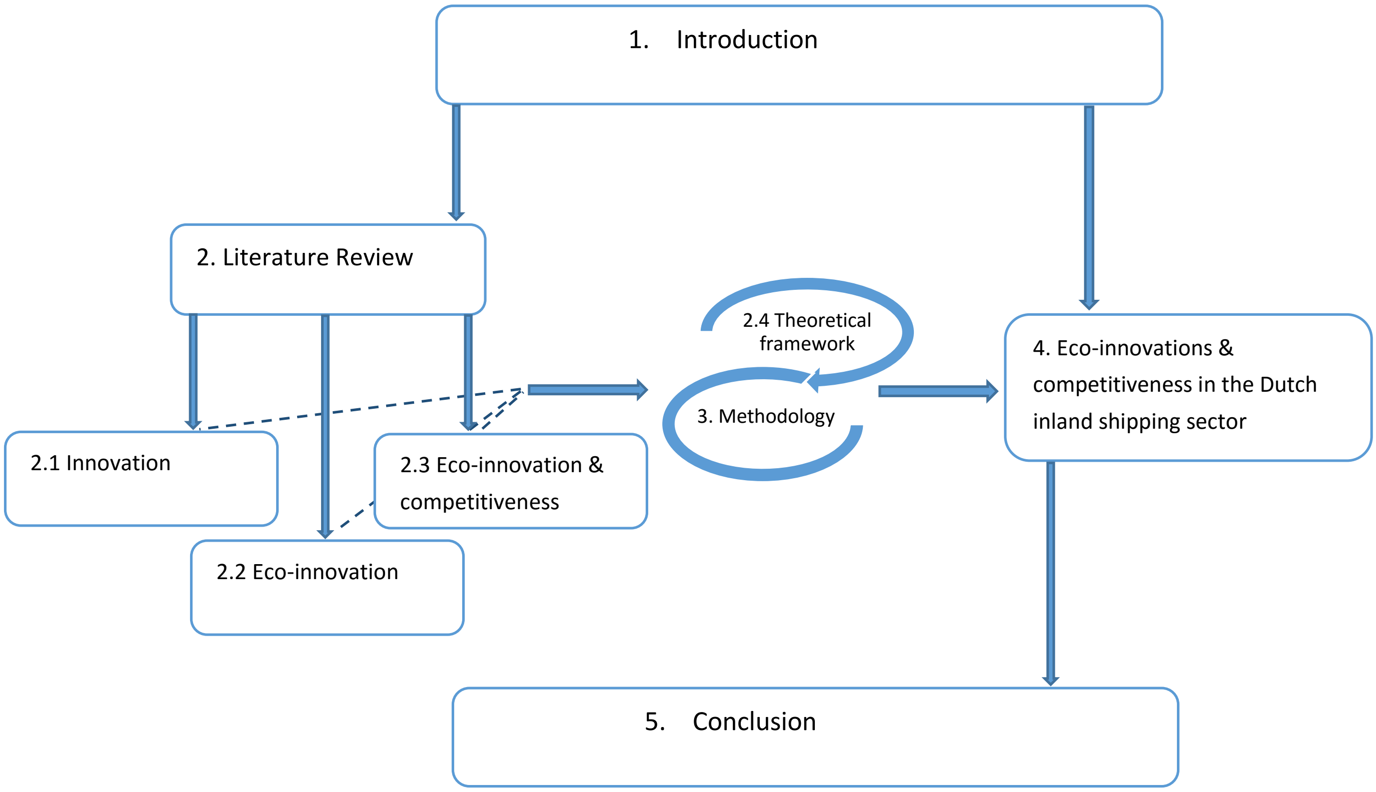
The abovementioned eco-innovations are thus the central units in this analysis and additionally there will be a focus on inland shipping companies. The effect of eco-innovations on the competitiveness will be analysed from the perspective of inland shipping companies. The perspective of inland shipping companies is without a doubt indispensable and the most important source of data, while it is the inland shipping company which innovates and experiences the effects upon its competitiveness.

1.6 Structure

This thesis is structured as follows. The second chapter discusses the literature review, the review can broadly be divided into four parts: innovation, eco-innovation, eco-innovation and competitiveness and the theoretical framework. The literature review will explain the concepts of innovation, eco-innovation and competitiveness, and will link eco-innovation to competitiveness. This will provide answers to the first three sub-questions and thereby helps building the theoretical framework which will be used for the empirical part of the research. The theoretical framework provides a perspective to look at reality and to structure the analysis. The theoretical framework consists of three parts; determinants for eco-innovation, competitiveness indicators, and indicators for sustained competitiveness. Chapter three discusses the methodology of this research, providing more insight into the used methods.

Chapter four discusses the relevant eco-innovations in the inland shipping sector and the results of the interviews. With that, chapter four provides an answer to the fourth and fifth sub-questions. Chapter four is divided into subchapters, a subchapter is reserved for each stated eco-innovation. The body of each subchapter is divided into three parts and will discuss the determinants, the effects on the competitiveness and whether it will be possible to sustain the effects on the competitiveness. The fifth chapter contains the conclusion, this chapter summarizes the contents of the first four chapters, provides an answer to the central research question, discusses the limitations of the research, and provides recommendations for further analyses and for the branch organizations. The structure is illustrated in figure 1:

Figure 1: Structure of thesis



2. Literature review

Introduction

Chapter 2 discusses the literature review and is divided into 4 subchapters: 2.1 innovation, 2.2 eco-innovation, 2.3 eco-innovation and competitiveness, and 2.4 the theoretical framework arising from the first three subchapters. The literature review provides answers to the first three sub-questions and thereby provides the components necessary for building the theoretical framework, which will be used for the empirical part of the research (chapter 4). Chapter 2.1 is mainly meant to explain the concept of innovation before putting the focus on eco-innovation. Chapter 2.2 explains the concept of eco-innovations and provides an answer to the first sub-question. Various definitions of eco-innovation will be discussed, and different typologies and determinants of eco-innovation will be compared with each other. The typologies and determinants will be used to build the theoretical framework in subchapter 2.4. Subchapter 2.3 introduces and explains the concept of competitiveness and links this to eco-innovation by discussing through which factors eco-innovation can affect the competitiveness of an organisation. These factors will also be used in building the theoretical framework. Subchapter 2.3 provides also answers to the second and third sub-question. As stated, subchapter 2.4 will discuss the theoretical framework, which will be used for the case analysis.

2.1 Innovation

One of the founding fathers of innovation theory is Joseph Alois Schumpeter (Snellen et al. 2012). In his famous work 'The Theory of Economic Development' the concept of innovation is explained as follows:

The introduction of a new good or method of production, the opening of a new market, the conquest of a new source of supply and the carrying out of the new organisation of any industry (Schumpeter, J.A. 1934, p.66).

An organisation could improve their performance and competiveness by means of innovation. Innovation is therefore crucial for the continued existence of an organisation. This applies to companies that compete for profits and/or a larger share of the market (Cooper, 2005a) (Hamel & Prahalad, 1994) (Kaplan & Norton, 1992) but also to public parties that want to provide advanced services (Mulgan & Albury, 2003) (Hartley, 2005). Innovation thus occurs far beyond the border of research laboratories and is therefore not only about new products.

While innovation is an abstract term many definitions of innovation are available in the academic literature, ranging from very abstract to very specific ones. Evolutionary economists define it as an endogenous circumstance in our economy and it can mainly be defined as knowledge, whose formulation and utilization strongly depends on accessible resources like capabilities and time (Carillo-Hermosilla et al. 2009). Some other popular definitions are listed in table 1:

Table 1: Innovation definitions

Author	Definition
Nelson (1968)	Process by which **new products** and **techniques** are introduced into the economic system
Zaltman et al. (1973)	Any **idea**, **practice** or **material** appliance perceived as being **new** to the organizational unit that adopts it
Gee (1981)	**Process** by which, from an **idea**, an **invention** or the identification of a need, a **product**, **technology** or **service** is developed that is accepted **commercially**
Van de Ven (1986)	A **new idea**, which may be a combination of old ideas, a project that challenges the present situation, a formula or a unique approach that is **perceived** as being **new** by the individuals involved
Damanpour (1991)	Generation, development and implementation of **new** ideas or behaviours

OECD (1992)	Transforming an **idea** into a successful market **product**, **new** or **improved**, or a business **process** in industry and trade or a **method** of social service
European Commission (1995)	Means to produce, assimilate and operate a successful innovation in the economic and social fields that brings **new** solutions to problems and thus meets the needs of both individuals and society
Noria and Gulati (1996)	Any **policy**, **structure**, **method** or **process**, or any **product** or **market** opportunity seen by the manager of a unit as innovative
Freeman and Soete (1997)	Attempts to commercialize an **invention** (an **invention** being the discovery of **new methods** or **materials**, namely, the discovery of **new knowledge**)
Chen et al. (2004)	Introduction of a **new** combination of essential factors of production in the production system. It involves **new products**, **new technologies**, **new markets**, **new materials** and **new combinations**
OECD (2006)	Introduction of a **new** or significantly improved **product** (or **service**) **process**, marketing **method** or methods in organizational practices within the company, in the workplace or in foreign affairs

Source: (Salvado et al. 2013, p.25)

Looking at abovementioned definitions it appears that most of them highlight the same key aspects of innovation. The bold words demonstrate these similarities between the different definitions and according to most definitions innovation concerns products, processes, services, methods and techniques which are either new to the organisation developing it or adapting it.

Thus, in a certain sense there occurs a change in the way something is done. This change may either be radical or incremental of nature. Incremental innovations include relatively minor alterations to existing products, processes, etc., exploits the potential of established designs, and usually improves the domination of established organizations (Nelson and Winter, 1982) (Dewar and Dutten, 1986). Such innovations usually do not require advanced new technologies, though they do require substantial abilities and skills, and may create in time substantial economic benefits for the organisation implementing these innovations (Hollander, 1965). Radical innovations on the other hand require usually a much greater investment, and concern for e.g. new products and processes based on new ways of engineering and scientific principles. Such radical innovations are capable of destroying the dominance of established organizations, leading to the successful entrance of new organizations into the market or even the alteration of a whole sector (Dewar and Dutten, 1986) (Etlie et al., 1984) (Henderson and Clark, 1990).

However, determining whether an innovation is incremental or radical can be difficult in some cases. The introduction of a new product may not be new in all aspects and could concern a redesigned product with only limited new technical aspects. The level of analysis is another factor which could blur the distinction between radical and incremental innovations (Rothwell & Gardiner, 1988). For example, the transition from flash memory towards cloud storage may be radical for producers of flash memory hardware, but incremental for the broader computer value network in which memory is just an element (Carrillo-Hermosilla et al., 2009). Rothwell & Gardiner (1988) suggest in their work that only 10% of the innovations are truly radical. Porter, M.E. (1990) agrees with this view and argues that many innovations are incremental and rely on ideas which are actually not even 'new'.

Another point of interest with regard to the definitions is that some authors mention the term 'invention'. It is important to note that inventions and innovations are two different things. Authors like Johnson et al. (2002) and Freeman and Soete (1997) mention that innovations are inventions which are commercialized and introduced in the market. Inventions are thus basically promising ideas for products or services which are founded on new knowledge and only become innovations when they are successfully introduced into the market (Branscomb & Auerswald, 2002). It is therefore possible to speak about an invention-innovation transition, but this is not always the case while Schumpeter points out that innovations are possible without inventions and that inventions do not always lead to innovations (Schumpeter, J.A., 1939).

A third notable point is that not all authors use the same perspective in defining innovation, most definitions approach innovation from an economic point of perspective. Only some of the definitions highlight the social[2] (e.g. Damanpour 1991) and socio-economic aspects (e.g. European Commission 1995). The definitions oriented on socio-economic aspects are the most relevant for this study. While being at the crossroads of environmental economics and innovation economics, eco-innovation mainly highlights socio-economic aspects. An eco-innovation can namely be considered as an economic change with a social impact, caused by the innovation's positive effect upon the environment. This will be extensively discussed in subchapter 2.3.

[2] Social innovation is not exactly the focus of this research but it is worth mentioning that the idea of social innovation is relatively new and is gaining increasingly more attention among scientists and the public sector (Rennings, 1999);(Hubert, 2010). Very broadly defined, social innovations concern innovations with the objective to meet social needs and are therefore not necessarily introduced in the market for commercial purposes (Phills, J., 2009). Examples are changes in lifestyle and consumption patterns (Scherhorn et al., 1997). Social innovations play an indispensable role in the development towards a sustainable future, while many of the current problems concerning the environment are not problems which can be solved solely by technological innovations (Duchin, 1999);(Rennings, 1999).

Conclusion

The objective of this subchapter is explaining the concept of innovation before putting the focus on the concept of eco-innovation. It appeared that innovation, not to be confused with invention, is in a certain sense a change in the way something is done. This change may be either incremental or radical to the organization adapting or developing it. This change may come in the form of a new good, process, method, market, resources and organisation. Organisations may introduce innovations into the market purely for economic reasons. However, next to economic effects innovations may also have social and socio-economic effects. In the case of eco-innovations it can be stated that these innovations mainly have socio-economic effects, while eco-innovations can be considered as economic changes with a social impact.

2.2 Eco-innovation

The need for eco-innovations

It has been more than two decades since the United Nations Conference on Environment and Development in Rio de Janeiro, and the concept of sustainable development is more important than ever. This subject receives significant attention among politicians and economists, while the global economy, society and natural environment are mutually dependent on each other and currently economic growth is not sustainable. The ongoing global economic growth deteriorates the negative impact on the natural environment. Some of the main problem areas and the according sectors are stated table 2:

Table 2: Main problem areas and sectors

Main problem areas	**Main sectors**
Greenhouse effect	Energy
Depletion ozone layer	**Mobility**
Acidification	Waste
Eutrophication	
Toxic impacts on media/ecosystems	
Toxic impacts on humans	
Loss of biodiversity	
Use of soil, land	
Resource use	

Source: (Rennings, 1999)

The bold words are relevant for the inland shipping sector. It can be seen that 'mobility' is in bold letters while the inland shipping sector is a sub-sector of the broader mobility and transport sector. Regarding the main problem areas for this sector, it can be stated that the 'greenhouse effect' is one of them. The emitted CO_2 emissions are the main driver of the greenhouse effect, however this problem is less significant for the inland shipping sector as compared to the road transport sector, which can be regarded as its main competitor (Panteia, 2013).

Secondly, pollutant emissions form a much more significant problem in the inland shipping sector as compared to the road transport sector. These pollutant emissions result in 'toxic impacts on humans' and can lead to serious health problems. Policies are set up on European and National level to reduce these emissions, while they result in significant external costs (Panteia, 2013).

A third main problem area which applies to the inland shipping sector, and the broader mobility and transport sector, is the 'resource use' which mainly consists of fuel consumption. Fuel consumption is interrelated with greenhouse effects and toxic impacts, while it is positively related with these externalities. The Dutch transport and mobility sector is responsible for 12% of total energy consumption in the Netherlands (ING, 2013). Despite the fact that the inland shipping sector accounts for a relatively small share as compared to other modalities, it still forms a significant volume in absolute terms (CBS, PBL, Wageningen UR, 2015).

The abovementioned environmental problems in the inland shipping sector and as well as other sectors should not be neglected. Over time these problems will result in major unsustainable trends which may in turn unavoidably lead to a significant deterioration and a societal collapse at the global stage (Carrillo-Hermosilla et al., 2009).

Definitions

The possible consequences mentioned above illustrate the need for sustainable development in order to prevent ecological disasters and provide the current and future generations a better world to live in. The global economy has to move along a more sustainable path. Therefore, increasingly more attention is being paid to innovations capable of contributing to this objective, also called eco-innovations. Just like normal innovations, eco-innovations may come in forms like new products, processes and services. Different from normal innovations though, eco-innovations contribute to the environmental performance of an organisation, in turn generating positive external effects for the society. Similar to innovation, eco-innovation is also an abstract term and is therefore defined in different ways by various academics. Some of these definitions are given in table 3.

Table 3: Definitions of eco-innovation

Author	Definition
Fussler, C. and James, P. (1996)	Eco-innovation is the process of developing **new products, processes or services** which provide customer and business value but significantly decrease **environmental impact**
James, P. (1997)	**New products and processes** which provide customer and business value but significantly decrease **environmental impacts**
Andersen, M.M. (2002)	Eco-innovation is Innovation which is able to attract **green rents** on the market
Arthur D. Little (2005)	The creation of **new market space, products** and **services** or **processes** driven by **social**, **environmental** or **sustainability** issues
Europe INNOVA (2006)	Eco-innovation is the creation of novel and competitively priced **goods**, **processes**, **systems**, **services**, and **procedures** designed to satisfy

	human needs and provide a better quality of life for all, with a life-cycle minimal use of **natural resources** (materials including energy, and surface area) per unit output, and a minimal release of **toxic substances**
Charter, M. and Clark, T. (2007)	A process where **sustainability** considerations (environmental, social, financial) are integrated into company systems from idea generation through to research and development (R&D) and commercialisation. This applies to **products**, **services** and **technologies**, as well as new **business** and **organisation models**
European Commission (2007)	Eco-innovation is any form of innovation aiming at significant and demonstrable progress towards the goal of **sustainable** development, through reducing impacts on the **environment** or achieving a more efficient and responsible use of **natural resources**, including energy
Kemp and Pearson (2008)	Eco-innovation is the production, assimilation or exploitation of a **product**, production **process**, **service** or management or business **method** that is novel to the organization (developing or adopting it) and which results, throughout its life cycle, in a reduction of **environmental** risk, **pollution** and other negative impacts of **resources** use (including energy use) compared to relevant alternatives
Oltra and Saint Jean (2009)	In a broad sense, eco-innovations can be defined as innovations that consist of **new** or **modified processes**, **practices**, **systems** and **products** which benefit the **environment** and so contribute to **environmental sustainability**
OECD (2009)	Eco-innovation is generally the same as other types of innovation but with two important distinctions: 1) Eco-innovation represents innovation that results in a reduction of **environmental impact**, whether such an effect is intended or not; 2) The scope of eco-innovation may go beyond the conventional organizational boundaries of the innovating organization and involve broader **social** arrangements that trigger changes in existing socio-cultural norms and institutional structures

Source: Own elaboration

Due to the broad scope of eco-innovation, and innovation in general, it can be approached from different perspectives. The definitions in table 3 are as result not identical, some are for e.g. very precise and state only the aspect of ‘green rents’ (Andersen, M.M. 2002), while other definitions are broader and incorporate also the social aspects of eco-innovation which are beyond the firm’s boundary (OECD, 2009). However, they all stress the same key aspect; namely that eco-innovations concern, just like normal innovations, new products, processes, etc., and that these innovations primarily aim to benefit the environment (Salvado et al., 2013). It is the environmental impact that principally describes eco-innovation and therefore refer to it as an innovation that improves the environmental performance. This is an indispensable aspect that all authors share in their definition. Some go beyond this aspect and also incorporate the potential social and economic impact that may occur as a result of the eco-innovation in their definition, like in the definitions of the OECD (2009) and the European Commission's INNOVA initiative (2006). Eco-innovations may indeed provide outcomes which are beneficial for both the society and the innovating firm. For example, an eco-innovative ship engine may consume less fuel and emit less emissions, providing economic benefits for the innovating firm and social returns for the society.

An important point to mention with regard to eco-innovations, and also innovations in general, is that the term is a relative concept. Unfortunately, this appears to be missing sometimes in the academic literature. Some of abovementioned definitions only stress the creation or production of new products, services, etc. However, an organisation can also innovate by acquiring and implementing an existing clean-technology for the first time into their business process. Therefore, a distinction can be made between innovations form an adapter's point of perspective and from a manufacturer's point of perspective (Arundel & Kemp, 2009).

A second important point to mention is that the literature on eco-innovation puts the focus mainly on eco-innovations in the secondary sector. This is unfortunate while the focus of this research is on inland shipping, which is a service and belongs to the tertiary sector. However, research shows that the innovative behaviour of manufacturing and service providing companies are in line with each other (del Val Segarra-Oña & Peiró-Signes, 2013). This is an important observation, while it means that the literature and frameworks focusing on eco-innovations for manufacturing firms may also be used for firms in the tertiary sector.

Typology of eco-innovations

The definitions provide a broad meaning and give a first idea on eco-innovations. However, in order to give a precise definition and distinguish the different types of eco-innovations it is useful to draw up a categorization. The academic literature provides a couple of categorizations with respect to eco-innovations, five of them are illustrated in table 4.

It appears that most of the typologies categorize eco-innovations based on the innovation's characteristics. Only the typology of Carrillo-Hermosilla et al. (2009) differs a bit from the rest, while it also takes the environmental impact into account in view of radical or incremental change.

However, not all aspects of the typologies in table 4 are relevant for the categorization of the stated eco-innovations in the inland shipping sector. For example, social and institutional innovations are beyond the scope in this case. Furthermore, while inland shipping companies merely provide services and are no producers of any goods, it can be stated that product eco-innovations are also not relevant. The framework of Carrillo-Hermosilla et al. (2009) is also not completely appropriate for this study. For example, an eco-effective innovation, as presented in table 4, is a very radical innovation which aims to alter the whole system in order to make it biocompatible. However, none of the stated eco-innovations in the inland shipping sector can be defined as an eco-effective solution.

Consequently, an own framework is set up which will categorize the eco-innovations based on their characteristics and environmental impact. Given the characteristics of the stated eco-innovations, they can be categorized into either organizational or technical process eco-innovations. Organizational eco-innovations are less technical and more human-centered (e.g. environmental management and auditing systems). Technical process eco-innovations aim to improve the environmental performance of processes. In case of this research it concerns the process of power generation for the propulsion of the ship. Technical process eco-innovations can in turn be divided into end-of-pipe and cleaner technologies as stated by Salvado et al. (2013) or component addition (end-of-pipe) and sub-system change (eco-efficiency) as stated by Carrillo-Hermosilla et al. (2009). Despite the fact that these subdivisions are named differently the contents are quite similar. This division may be inspired by the older academic literature, such as the studies of Schmidheiny (1992) and Smart (1992), who made a division between cleaning emissions at the 'end-of-the-pipe' (e.g. catalytic converters and particulate filters) and preventing/reducing emissions during the process itself by (partly) adjusting (e.g. hybrid propulsion) it. The relevant framework will be discussed in subchapter 2.4 for the theoretical framework.

Table 4: Typologies of eco-innovation

Typology of Rennings, K (1999)	Typology of Debref, R (2012)	Typology of Kemp, R & Pearson, P (2007)	Typology of Salvado et al. (2013)	Carrillo-Hermosilla et al. (2009)
Technological Organizational Social Institutional	New goods New production methods New work organizations New outlets New raw materials	Environmental technologies Organisational innovation Product and service innovation Green system innovations	Organizational Technical: - Product - Process: -end-of-pipe -cleaner production	Component addition (end-of-pipe) Sub-system change (eco-efficiency) System change (eco-effectiveness)

Source: Own elaboration

Determinants of eco-innovation

In analysing the effects of eco-innovations on the competitiveness of an organisation, it is helpful to know which factors drive an organisation to innovate. It could be argued that innovation is first and foremost a question of willingness to change. This is an important aspect discussed by Ashford (2002). The author states that three elements are indispensable for any change to occur. These three elements are the willingness to change, the opportunity to change and the capacity to change (Ashford, 2002). With this theory the author actually highlights the importance of internal factors for any innovation to occur. Regarding eco-innovations it may appear that external factors are also indispensable. Moreover, every organisation may have their own unique set of determinants, which helps to explain why some organisations innovate more than others, the way they innovate and the impact it may have on the competitiveness. The academic literature provides a couple of studies on the determinants for eco-innovations, five of these studies will be discussed and are illustrated in table 5.

The theories of Rennings, K (1999), Doran, J & Ryan, G (2012) and Montalvo, C (2008) are strongly in line with each other while they all stress the interplay of three determinant categories: the technology push (supply side drivers), market pull (demand side drivers) and the regulatory push (regulations). The theory of Carrillo-Hermosilla et al. (2009) differs a bit from the abovementioned theories while it mentions the characteristics of the technology as a separate determinant for eco-innovations. This theory is the most relevant one for the cases in this thesis, which will be discussed in the coming sections. The theory of Kemp, R and Volpi (2007) differs the most from the others, while it stresses the interplay of endogenous and exogenous mechanisms.

Kemp, R and Volpi (2007) argue that the dissemination of eco-innovations is driven by factors endogenous to the dissemination and factors exogenous to it. Determinants like energy prices, regulations and market structure are exogenous determinants, whereas awareness about the eco-innovation and learning economies leading to price-reduction are endogenous determinants. As compared to the other theories, this one analyses the adaptation and dissemination of eco-innovation less from the firm’s point of perspective. The focus is merely on the diffusion of eco-innovations itself and less on specific determinants for eco-innovations within the firm. However, the contents of the exogenous and endogenous mechanisms are to a certain extent in line with the determinants as mentioned in the other theories.

The theories of Rennings, K (1999) and Doran, J & Ryan, G (2012) and Montalvo, C (2008) are strongly in line with each other. The determinants are defined in a different way but actually highlight the same thing. Rennings, K (1999) and Doran, J & Ryan, G (2012) argue that the decision of a firm to eco-innovate is determined by the interplay of three factors: the technology push (supply side drivers), market pull (demand side drivers) and the regulatory push (regulations). The seven determinants of Montalvo, C (2008) can actually be grouped together into three drivers as mentioned by Rennings, K (1999) and Doran, J & Ryan, G (2012). The first determinant 'policy' can be seen as the regulatory push. The determinants 'economics', 'markets', 'communities & social pressure', and 'attitudes & social values' form together the market pull (demand side drivers). The remaining determinants 'technological opportunities & capabilities' and 'organisational capabilities' form together the technology push (supply side drivers).

Carrillo-Hermosilla et al. (2009) also drew up a triangular model, consisting of external factors, internal factors and characteristics of the technology. This theory actually builds on the triangular model of clean technology adoption as stated by Del Rio Gonzalez (2005). It is stated in this theory that the decision to adapt a clean technology depends on the interaction of external factors, internal factors, and main characteristics of the clean technology. These three determinant categories are in turn made up out of a number of determinants. Some examples of external determinants are public policy, economic climate and customers. Internal determinants consists of factors like the firm's financial situation, technological competency, environmental strategy and organizational factors. Characteristics of the technologies as third determinant consists of factors like potential benefits, costs and cost-savings.

It appears that the theory of Carrillo-Hermosilla et al. (2009) puts relatively more focus on the characteristics of eco-innovations as compared to the other theories, while it defines this as a separate determinant category. A possible reason could be that this theory puts an explicit focus on the adaptation of eco-innovations, rather than on both development and adaptation. When a firm wants to adapt an existing clean technology and thereby has a choice between different technologies, the characteristics of these different technologies will play an important role.

Table 5: Determinants of eco-innovations

Rennings, K (1999)	Doran, J & Ryan, G (2012)	Kemp, R & Volpi, M (2007)	Montalvo, C (2008)	Carrillo-Hermosilla et al. (2009)
Technology Push Regulatory Push Market Pull	Demand side drivers Supply side drivers Regulation	Endogenous mechanisms Exogenous mechanisms	Policy Economics Markets Communities & social pressure Attitudes & social values Technological opportunities & capabilities Organisational capabilities	External factors Internal factors Characteristics of the technology

Source: Own elaboration

The discussed theories are closely related to each other and do not differ that much, while these theories are most likely based on the older academic literature on determinants for normal innovations. For example, authors like Schmookler (1966), Mowery & Rosenburg (1979) and Pavitt (1984) highlighted that innovative activity is determined by the interplay of technology push (supply side drivers) and market pull (demand side drivers) factors. The presence of both drivers is a necessary condition for any innovation to become successful. However, with regard to eco-innovations the additional presence of regulations is almost indispensable (Porter & van der Linde, 1995);(Rennings, 1999);(Carrillo-Hermosilla et al., 2009). The importance of regulations can partly be explained by the double-externality problem[3]. Next to that, regulations fulfil also an important role in translating the demand for sustainability into precise regulations and providing (polluting) firms with specific guidelines and requirements (Kemp, 2000).

Despite the similarities among the discussed theories, the theory of Carillo-Hermosilla et al. (2009) is the most applicable to the cases in this research. This theory explicitly puts the focus on the adaption of eco-innovations, which is consistent with the focus of this study. The effects of the stated eco-innovations on the competitiveness will be analysed from the perspective of inland shipping companies who are adapting these eco-innovations rather than developing them. Therefore, the characteristics of these eco-innovations act as an important determinant, earning the right in this study to be mentioned as a separate determinant category of eco-innovations. A second advantage of this theory as compared to the other ones is that it's formulated in such a way which makes it very appropriate to analyse both the drivers and barriers of eco-innovations. Whereas the theories of Rennings, K (1999) and Doran, J & Ryan, G (2012) are predominantly meant to determine the drivers of an eco-innovation. The triangular model, consisting of external factors, internal factors and characteristics of the technology will therefore be used in analysing the determinants for the cases in this research.

[3] The double-externality problem refers to the positive externalities occurring during the innovation and diffusion phases. The positive spill-overs to other firms and the positive impacts upon the environment cause that social returns exceed the private returns for the innovating company. There is a missing price which is required for the internalization of the externalities. Governmental interference is necessary to alter this double-externality situation, either through market-based instruments (e.g. taxes and subsidies) or non-market based instruments (e.g. emissions standards).

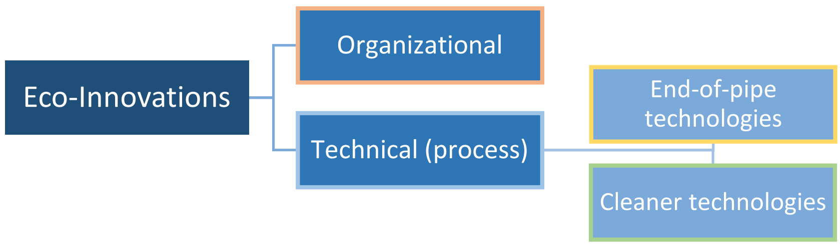
Conclusion

The main objectives of this subchapter are explaining the concept of eco-innovation and thereby providing an answer to the first sub-question, and providing components for the theoretical framework.

The first sub-question of this research is: 'what is eco-innovation, and why is it relevant?' Eco-innovations are in the first place innovations, thus in a certain sense there occurs a change in the way something is done. As discussed in subchapter 2.1, this change may come in the form of a new product, process, method, market, resources and organisation. However, different from standard innovations, eco-innovations primarily aim to benefit the environment. It is the environmental impact that principally describes eco-innovation. Global environmental problems and its major consequences for the society highlight the need for eco-innovations in all industries, but above all in energy intensive and polluting industries like the mobility and transportation industry, of which the inland shipping sector is part of.

It appeared from the literature that just like normal innovations, it is also possible to categorize eco-innovations, both based on their characteristics and environmental impact. Components from the discussed literature on typologies will be used to build the theoretical framework, which in turn is relevant for the categorization of eco-innovations in the inland shipping sector. As discussed before and illustrated in figure 2, the stated eco-innovations in this study will be categorized into technical process and organizational eco-innovations. Within the category of technical process eco-innovations there will be a further division into either end-of-pipe or cleaner technologies. This categorization will happen in view of the environmental performance of the eco-innovation.

Figure 2: Typology based on characteristics



Finally, the determinants for eco-innovations are discussed. For the analysis on the relationship between eco-innovations and competitiveness it is helpful to know which factors drive or act as a barrier for an organisation to innovate. This may already indicate whether the eco-innovation has an effect on the competitiveness and whether certain actors like the government and customers stimulate or hinder the company to innovate. As discussed, the theory of Carrillo-Hermosilla et al. (2009) is the most useful in determining the determinants for the cases in this thesis. The determinants are broadly divided into external factors, internal factors and characteristics of the technology. These three determinants are in turn made up out of a number of factors, which is illustrated in table 6, and will be used in the theoretical framework.

Table 6: Determinants for eco-innovations

DETERMINANTS		
EXTERNAL	INTERNAL	CHARACTERISTICS OF ECO-INNOVATION
Public policy	Financial situation	Costs and cost-savings
Economic climate	Characteristics of the sector	Complexity and compatibility with existing systems
Suppliers	Technological competency (absorption capacity)	Existence of an installed base
Customers	Environmental strategy and organizational factors	Complementary innovations
Competitors	Company size	Expectation of cost reductions and quality improvements
Financial institutions		
Availability of information		
Research centers		
Industrial associations		
Civil society (larger public)		

Source: Own elaboration

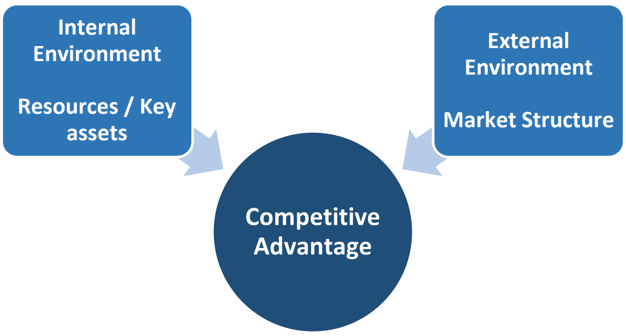
2.3 Eco-innovation and competitiveness

Theories for competitive advantage

Regarding the relationship between the environmental performance and competitiveness, two popular views can be found in the academic literature; the 'traditionalist' view and the 'revisionist' view. According to the traditionalist view there is a trade-off between improving the environmental performance and improving the competitiveness. On the other hand, the 'revisionist' view argues that there is rather a positive relationship between environmental performance and competitiveness. The 'Porter hypothesis' is a famous example of this view. Porter & van der Linde (1995) view the positive relationship from a regulatory point of perspective and state that strict environmental policies may force companies to eco-innovate. Eco-innovations may in turn simultaneously improve the environmental performance and the competitiveness of the company.

In order to determine which view applies to the stated eco-innovations in relation to their effects on the competitiveness of inland shipping companies, it is necessary to first define what competitiveness exactly is and how it can be measured. There is no clear literature on the definition of competitiveness (Wagner & Schaltegger, 2004). The concept can be explained in terms of the ability of an organisation to gain advantages over his competitors, also called competitive advantages. In order to understand the dynamics of competitive advantages, it is necessary to discuss the literature on this topic. As illustrated in figure 4, theories on competitive advantage can roughly be divided in two different views: the Market-Based View (MBV) and the Resource-Based View (RBV). These two theories should not be seen as competing theories, while they rather complement each other (Wang, 2014).

Figure 3: MBV, RBV and competitive advantages



Source: own elaboration

The MBV highlights the external environment of the company and relates potential competitive advantages to the ability of a company to position itself in the market, companies develop strategies in response to the structure of the sector it operates in. A firm's performance is therefore strongly dependent on the industry environment it operates in. Popular theories in this category are the 'structure conduct performance theory' developed by Bain (1959) and especially the 'five forces theory' of Porter (2002).[4]

The RBV on the other hand, puts the focus on the internal environment and states that endogenous factors are relevant for the performance of a firm, while competitive advantage depends on the resources and capabilities of a firm. Authors like Penrose (1959); (Barney, 1986); (Wernerfelt, 1984); (Rumelt, 1991) argue that the resources and capabilities of a firm are certainly more relevant for the competitive advantage than the sector structure is.

The concept of resources is explained in a different way by various academics. Ansoff (1965) was among the early authors to discuss this concept and categorized resources into physical, monetary and human factors. Wernerfelt (1984) argued that resources could be anything belonging to the strengths and weaknesses of a company. Barney (2001) stated that resources are all tangible and intangible assets of a firm, used to determine and apply its strategy and gain competitive advantage. The stated eco-innovations adapted by inland shipping companies can be seen as resources. Energy efficient navigation (VoortVarend Besparen) forming an intangible asset, whereas the other four are tangible assets.

Capabilities are in turn the things which a company can implement thanks to the resources it possesses. Amit and Schoemaker (1993) argue that capabilities belong to a company's ability to couple and utilize resources by organizational practices in order to realize the company's objectives. Thus the resources actually serve as input for a company's capabilities. The reduction of pollution thanks to a hybrid propulsion is an example of a capability. Firms which obtain valuable (rent creating) and rare (not widely distributed in the sector and/or specific to a firm) resources will be able to gain competitive advantages and improve the competitiveness. However, in a competitive environment the created advantages may only be temporary while there is no guarantee that these will hold in the long run. In order to create sustainable competitive advantage, the resources also have to be difficult to replicate by competitors and they have to be non-substitutable, while resources which are of significant value should have no alternatives (Hart S. , 1995);(Salvado, Castro, Lopez, & Verde, 2013). Another way to sustain the created competitive advantage is by engaging in

[4] The five forces theory enables a firm to analyse the situation of their sector according to the intensity of rivalry, threat of new entrants, threat of substitutes, power of suppliers and the power of buyers. The firm establishes a strategy (e.g. cost control in maritime transport industry) based on the outcome of this analysis (Midoro et al., 2005).

continuous development and continuously improve the resources and capabilities, while the creation of competitive advantages can be seen as a dynamic process (Forsman et al., 2013).

A shortcoming of the RBV is the lacking environmental perspective, which is pitiful given the current environmental concerns on a global scale and the scope of this study. As a result, Hart, S.L. used the RBV and imbedded environmental aspects into the theory. Once published in 1995 this new theory became known as the Natural Resource Based View of the firm (NRBV). Hart states in his work that resources and capabilities which take environmental concerns into account can result in competitive advantages. Capabilities like pollution prevention may enable a company to lower costs and in that way create a competitive advantage over its competitors (Hart, 1995); (Hart & Dowell, 2011). Next to pollution prevention, Hart discusses three more strategic environmental capabilities which make it possible to gain competitive advantages. However, these capabilities will not be discussed while they are not relevant for this research. The main purpose of discussing the NRBV though, is to show that an improved environmental performance related to the resources and capabilities of a company may go hand-in-hand with competitive advantages.

When comparing both theories it appears that the RBV and the NRBV derived from it are more related to the objective of this study as compared to the MBV. Once developed or adapted, eco-innovations belong to the resources of a firm which in turn enables capabilities like pollution prevention. Resources and capabilities are the two factors which are the basis for competitive advantages according to the RBV, whereas the MBV puts the focus on the external environment and is beyond the scope of this research. It is however important to mention that for a broader analysis on competitive advantages and competitiveness the MBV cannot be neglected. For example, the fragmented market structure of the Dutch inland shipping sector which consists of many small players, undoubtedly affects the freight rates and the financial position of inland shipping companies, which in turn either directly or indirectly may have an effect on the competitiveness of these companies. However, this is beyond the scope of this study while the focus is explicitly on the relationship between eco-innovations and competitiveness.

Measuring competitive advantages

In order to provide a concrete picture of the competitive advantages an eco-innovation may create, indicators of competitive advantages are indispensable. Table 7 presents some indicators for competitive advantages:

Table 7: Competitive advantage

Author	Indicators of competitive advantage
Porter and van der Linde (1995)	Superior productivity (e.g. in terms of lower costs than rivals) and the ability to offer superior value to customers (justifying a premium price)
Judge and Douglas (1998)	ROI (Return On Investment), income, sales, change of market share in comparison to competitors
Christmann (2000)	Cost advantage
Karagozoglu and Lindell (2000)	Competitive advantage (cost, quality, reputation and international competition)
Roberts and Dowling (2002)	Image and reputation
Melnyk et al. (2003)	Operating income
Ann et al. (2006)	Economic and environmental impact, customer satisfaction and perceived market position
He et al. (2007)	Short-term market profitability (e.g., ROI, net profit, profit increase, and net profit growth compared to competitors) and long term-growth potential (e.g., increased cash flow, sales, revenue growth, and market share)
Carrillo-Hermosilla et al. (2009)	Cost advantage, environmental compliance, creation of new markets or segments, improved image and relationship with customers, suppliers, authorities and employees
Lopez Gamero et al. (2009, 2010)	Cost competitive advantage, differentiation competitive advantage, firm performance (add value gain, economic performance, financial performance)
Menguc et al. (2010)	Perception measures: firm performance (sales increase and profit gain)

Source: Own elaboration

It can be seen from table 7 that almost all indicators stress economic factors such as costs, profits, revenue and ROI. Indicators as image and reputation can be defined as intangible assets which may be difficult for competitors to imitate (in the short term) and in turn allows a firm to maintain its competitive position and differentiate itself from the competition. This may perhaps have no direct effect on the economic performance of a firm, but will over time generate positive economic returns (Roberts & Dowling, 2002).

Wagner, M (2009) clustered these indicators into four dimensions: market-related, image-related, efficiency-related and risk-related competitiveness. Market-related competitiveness concerns indicators as market share, sales and new market opportunities. Image-related competitiveness refers to the abovementioned discussion on image and reputation and includes indicators as corporate image, owner and management satisfaction, and as well as worker satisfaction. Efficiency-related competitiveness relates to factors as improved productivity, positive ROI, improved profits and cost advantages. Risk-related competiveness relates to the improved relations of the firm with its external stakeholders, like the government, media and communities. A better environmental performance of the firm undoubtedly contributes to such improvements with its external stakeholders, this reduces in turn the risks related to these relationships. Examples are less negative media attention and lower risks for penalties as result of breaching (coming) environmental regulations. It could even be the case that firms push for tighter environmental regulations in order to profit from first mover advantages (Ambec & Lanoie, 2008). It could be argued that this last dimension is mainly relevant for relatively large firms in energy intensive industries, like power plants and chemical plants. Such firms generally have a sensitive relationship with the government, media, communities and environmental organizations. As compared to the other dimensions, this dimension may be not that relevant for inland shipping companies. However, this dimension cannot be completely neglected while it has some relevance, as certain environment related penalties also exist for inland shipping companies. For example, inland ships which are not able to meet the CCR-2 emission norm have to pay higher port dues in certain ports. Another risk is that by 2025 inland ships have to meet at least the CCR-2 emission norm, otherwise they will be prevented from entering the port of Rotterdam and approximately 50% up to 80% of the Dutch inland ships regularly call in at the port of Rotterdam (Rijkswaterstaat, 2013).

These four competitiveness related dimensions (market, image, efficiency and risk), provide a well-ordered overview of the different types of impact upon the competitiveness as result of the eco-innovations. The idea of four dimensions is also applicable to this study on the inland shipping sector and will therefore be used in order to analyse the relationship between each eco-innovation and the competitiveness of the company adopting the eco-innovation.

Conclusion

The main objectives of this subchapter are relating the concept of eco-innovation to competitiveness, answering the second and third sub-questions, and thereby providing components for the theoretical framework.

The concept of competitiveness is explained in terms of advantages over competitors, also called competitive advantages. This discussion concerns the second sub-question 'How can competitive advantages be obtained?' Two important views exist concerning the theories on competitive advantages, namely the MBV and the RBV. According to the MBV competitive advantages and the competitiveness of a firm, depend to an important extent on the external environment and the strategies based on this external environment. On the other hand, the RBV states that competitive advantages lie within the company and its resources and capabilities. When these resources and capabilities are valuable and rare, a company will be able to gain competitive advantages and improve its competitiveness. In order to sustain this competitive advantage over time the resources also have to be difficult to replicate by competitors and they have to be non-substitutable for the innovating company. This is an important conclusion which will be used in determining whether eco-innovations in the inland shipping sector also create sustained competitive advantages. The factors of inimitability and non-substitutability will therefore also be included in the theoretical framework. It can lastly be stated that the MBV and RBV are complementary views and it can therefore be stated that competitive advantages are obtained both through strategies based on the external environment and by obtaining resources and capabilities as mentioned above.

Subchapter 2.3 also provides an answer to the third sub-question, 'How does eco-innovation affect a company's competitiveness?' Once adapted or developed, an eco-innovation belongs to the resources of a company, in turn making capabilities as pollution prevention possible. As shown with the NRBV, such resources and capabilities which take environmental concerns into account can result in competitive advantages and thereby enable a company to improve its competitiveness. As illustrated in table 7, these competitive advantages may come in various forms like market share increases, reduced costs, improved image and reputation. These advantages can in turn be grouped into the market-related, image-related, efficiency-related and risk-related competitiveness. Therefore, an own table (table 8) is set up for the analysis of the cases in this study.

Table 8: Indicators for competitiveness

COMPETITIVENESS			
MARKET	IMAGE	EFFICIENCY	RISK
Market share	Relationship with customers, suppliers and authorities	Cost savings	Environmental compliance
Sales (load)	Owner and management satisfaction	Revenue growth	
New market opportunities	Worker satisfaction	Profit growth	
		Return On Investment (ROI)	

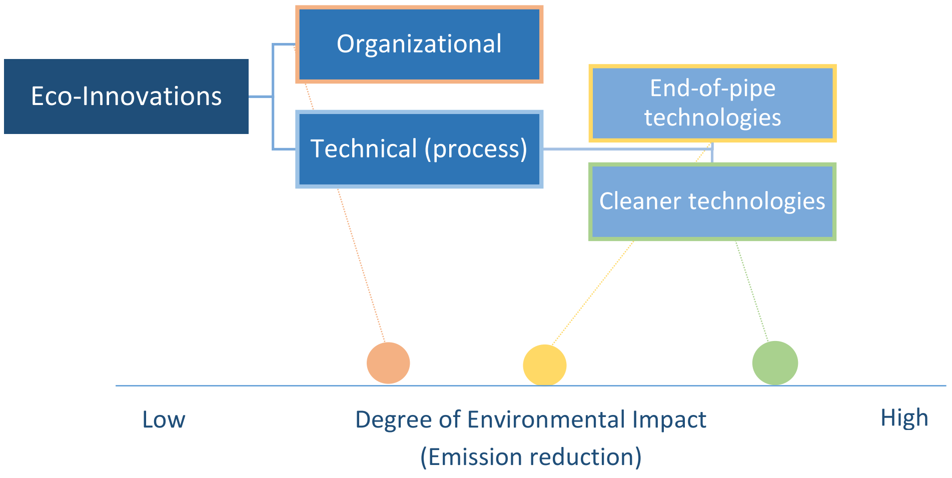
Any improvement in these categories as a result of the eco-innovation, will contribute to the overall competitiveness of the innovating company. These indicators for competitiveness will also be included in the theoretical framework and will be used in the empirical part of the thesis.

2.4 Theoretical framework

Introduction

This subchapter will combine and present the building blocks for the theoretical framework as discussed in subchapters *2.2 eco-innovation* and *2.3 eco-innovation and competitiveness*. The theory discussed in these chapters will be used for the analysis in the empirical part (chapter 4) of the thesis. First of all, the typology as discussed in subchapter 2.2 will be used to shortly categorize each stated eco-innovation in this study, based on their characteristics and environmental performance. The main objective of this categorization is to provide some background information on each eco-innovation. Figure 4[5] will be used to illustrate this categorization.

Figure 4: Typology based on characteristics & environmental impact



Subchapter 2.2 also provides components concerning the determinants and subchapter 2.4 provides in addition the indicators for (sustained) competitiveness. The theoretical framework is based on this theory and consists of three parts: the determinants, indicators for competitiveness and indicators for sustained competitiveness.

[5] Inserted bulbs are for illustrative purposes only. Please note that the position of these bulbs on the horizontal axis only provide a rough estimate of the environmental performance. The environmental performance is in turn based on the realisable emission reduction.

The theoretical framework

As discussed in subchapter 2.2, for the analysis on the relationship between eco-innovations and competitiveness it is helpful to know which factors drive or act as a barrier for an organisation to innovate. This may already indicate whether the eco-innovation has an effect on the competitiveness and whether certain actors like the government and customers stimulate or hinder the company to innovate. The determinants are broadly divided into three categories: external factors, internal factors and characteristics of the eco-innovation. These three determinant categories are in turn made up out of a number of factors. Relevant factors are displayed in table 9 and will be used for the interview questions, which will be discussed in chapter 3 methodology.

The second step, and at the same time the key objective of this thesis, is analysing to what extent the eco-innovation affects the competitiveness. The concept of competitiveness is extensively explained in subchapter 2.3 and it is stated that eco-innovations may result in competitive advantages and thereby enable a company to improve its competitiveness. Relevant indicators for competitiveness are presented in table 9, these indicators will be used for the interview questions and will help to determine if and how eco-innovations affect the competitiveness of inland shipping companies.
As discussed in subchapter 2.3, the indicators for competitiveness are grouped into four dimensions: market-related, image-related, efficiency-related and risk-related competitiveness. This provides a well-ordered overview of the different types of impact upon the competitiveness as result of the eco-innovations.

The third step is analysing to which extent the eco-innovation generates a sustainable competitive advantage and enables the inland shipping company to sustain its competitiveness. According to the RBV, and as illustrated in table 9, this requires resources which are non-substitutable and inimitable. This means that the eco-innovation has to be non-substitutable for the company adapting it and difficult to replicate for the competitor, i.e. it should be difficult for the competitor to adapt the same eco-innovation. The factors of non-substitutability and inimitability will also be used for the interview questions in order to determine to what extent the created competitive advantages are sustainable.

Table 9: The theoretical framework

DETERMINANTS		
EXTERNAL	INTERNAL	CHARACTERISTICS OF ECO-INNOVATION
Public policy	Financial situation	Costs and cost-savings
Economic climate	Characteristics of the sector	Complexity and compatibility with existing systems
Suppliers	Technological competency (absorption capacity)	Expectations of cost reductions and quality improvements
Customers	Environmental strategy and organizational factors	Existence of an installed base
Competitors	Company size	Complementary innovations
Financial institutions		
Availability of information		
Research centers		
Industrial associations		
Civil society (larger public)		

COMPETITIVENESS			
MARKET	IMAGE	EFFICIENCY	RISK
Market share	Relationship with customers, suppliers and authorities	Cost savings	Environmental compliance
Sales (load)	Owner and management satisfaction	Revenue growth	
New market opportunities	Worker satisfaction	Profit growth	
		Return On Investment (ROI)	

SUSTAINED COMPETITIVENESS	
NON-SUBSTITUTABILITY	INIMITABILITY

3. Methodology

Approach

This part will explain the research design of the study, which puts the focus on eco-innovations in the Dutch inland shipping sector. The chosen research approach for this study covers qualitative methods. It is not easy to define the term 'qualitative research' while it is a broad term covering various techniques and philosophies. Broadly defined, this research approach is about examining persons' experiences in detail by means of interviews, discussions, observation, content analysis, visual methods and biographies (Denzin & Lincoln, 1994) and (Patton, 2002) in (Hennink et al., 2011). These experiences can be defined as qualitative data, i.e. information gathered in a non-numeric structure (Easterby-Smith et al., 2015). Key aspects of qualitative research are summarized in table 10:

Table 10: Qualitative research

	Qualitative research
Objective	To gain a detailed understanding of underlying reasons, beliefs, motivations
Purpose	To understand why? How? What is the process? What are the influences or contexts?
Data	Data are words (called textual data)
Study population	Small number of participants or interviewees, selected purposively (non-randomly)
	Referred to as participants or interviewees
Data collection methods	In-depth interviews, observation, group discussions
Analysis	Analysis is interpretive
Outcome	To develop an initial understanding, to identify and explain behaviour, beliefs or actions

Source: (Hennink et al., 2011, p. 16)

There are some reasons why the qualitative research approach is chosen above other approaches. First of all, the lack of (numerical) data plays an important role. Obtaining this data through for example online surveys is quite difficult. It appeared from previous experiences that obtaining data through surveys among inland shipping companies, in order to perform quantitative research, is a difficult path while the response rates are very low. An additional problem to this approach would be the sample size, while the number of existing eco-innovations relevant to this study are relatively small. It will also be problematic to quantify certain factors relevant to this study, such as image and relations, in order to place them in a model. Such models will make it also difficult to deal in a flexible way with unforeseen findings that might arise during the research (Yin, 2014).

Another advantage of qualitative research is that it allows the researcher to deeply explore behaviors, different perspectives, and thus provides a deeper understanding of the subject (Holloway & Wheeler, 2002); (Flick, 2009). This makes it a very appropriate method for this study, while very little is known about the eco-innovations itself, the innovation process, motives of inland shipping companies and the potential effects upon their competitiveness. It is therefore necessary to go into detail and tools like in-depth Interviews and discussions with experts in field will be an appropriate way to do this.

Case selection

Eco-innovations in the Dutch inland shipping sector are at the heart of this research. The stated eco-innovations are the central units in this analysis, these eco-innovations are as follows:

- LNG as alternative fuel
- Emission after-treatment of diesel engines (SCR&DPF)
- Right-sizing and hybrid propulsion
- Energy efficient navigation (VoortVarend Besparen)

According to the EU-funded project 'Promoting Innovation in the Inland Waterways Transport Sector' (PROMINENT) these are the best available greening technologies and concepts ready for mass introduction in the inland shipping sector. Within the categories of emission after-treatment and energy efficient navigation the focus will only be on SCR&DPF installations and the program VoortVarend Besparen (VVB), respectively. These eco-innovations have already been assessed to be particularly promising, while other initiatives within both categories are merely in their development stage (Maierbrugger, et al., 2015). It will therefore be difficult to evaluate the effects of these initiatives on the competitiveness.

The analysis is limited to the Netherlands mainly due to the fact that eco-innovations are relatively more present in the Dutch inland shipping sector as compared to other countries which also have a significant inland shipping sector, like Germany and Belgium. This makes it more practical to collect information on eco-innovation and to interview eco-innovative inland shipping companies.

Data collection

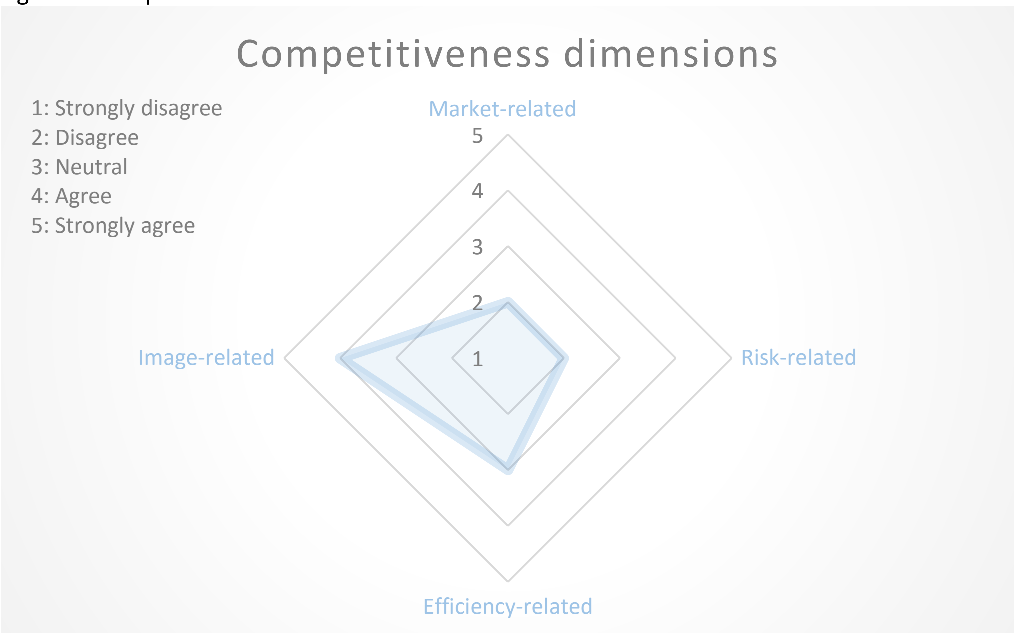
The necessary data for this research is collected in different ways. Desk research is one of them, data is obtained through (news) articles from specialist journals like the 'Schuttevaer' and 'Binnenvaartkrant'. Existing studies on related subjects (e.g. innovations in the inland shipping sector, emissions in the inland shipping sector and future environmental regulations) written by organisations like 'Panteia/NEA' and 'Ecorys' is a second source of data. Furthermore, discussions are held with experts belonging to the EICB, in order to acquire practical information about the eco-innovations, the inland shipping companies involved, existing environmental regulation, etc. The obtained information is used as input in chapter 4, mainly for the categorization of the stated eco-innovations. As discussed in the theoretical framework, this categorization is based both on the characteristics and environmental impact of the eco-innovations.

Furthermore, in-depth interviews have been conducted with inland shipping companies which have adapted the stated eco-innovations. The obtained data through these interviews will be at the core of chapter 4. The perspective of inland shipping companies is without a doubt indispensable and the most important source of data, while it is the inland shipping company which innovates and experiences the effects upon its competitiveness. In total 11 interviews have been conducted (see appendix); 3 for the eco-innovations LNG, SCR&DPF and VVB, and 2 for right-sizing and hybrids concepts together. Right-sizing and hybrid propulsion are closely related to each other, they are meant for the same target group and generate approximately the same emission reductions and fuel savings.

During these interviews several points of interest are dealt with (specific questions can be found in the appendix). The general outlines of the interview questions are based on the theoretical framework. First of all some general questions are asked about the inland shipping company and its activities. Secondly, questions are asked about the determinants for the adapted eco-innovations. This reveals the strongest drivers and barriers regarding the adapted eco-innovation. The determinants may already indicate whether the eco-innovation has an effect on the competitiveness and whether certain actors like the government and customers stimulate or hinder the company to innovate.

However, in order to provide a concrete picture of the effects on the competitiveness, questions are asked related to the competitiveness indicators, again based on the theoretical framework. The questions answer if and what kind of impact the eco-innovation has created on each mentioned competitiveness indicator. This also reveals which competitiveness dimension experienced the strongest impact. Figure 5[6] is used to visualize the view of inland shipping companies concerning their competitiveness. The scale processed in the figure is based on the Likert scale (Likert, 1932). In the end, the visualizations for each eco-innovation will be compared with each other.

Figure 5: competitiveness visualization



As last, questions are asked related to sustained competitiveness, again based on the theoretical framework. The answers on these questions reveal whether the adapted eco-innovations contribute to sustained competitiveness.

[6] Inserted data is for illustrative purposes only

4. Eco-innovations & competitiveness in the Dutch inland shipping sector

Introduction

Chapter 4 forms the core of this thesis and will discuss the stated eco-innovations and their effects on the competitiveness of innovative inland shipping companies. Each eco-innovation will be discussed in a separate sub-chapter, consequently there will be 4 sub-chapters. Every sub-chapter includes a broad introduction, meant to provide some background information and draw up a categorization of each eco-innovation. The body of each sub-chapter will discuss the determinants, the effects on the competitiveness and whether it will be possible to sustain the effects on the competitiveness. The body of each sub-chapter is therefore divided into three parts. As last, each sub-chapter will end with a conclusion.

Chapter 4 as a whole will also end with a conclusion, it will shortly summarize and compare the most important results among the 4 eco-innovations. This conclusion will also include an answer to the fourth and fifth sub-questions.

4.1 LNG

4.1.1 Introduction

Natural gas becomes LNG by cooling it down to -162ºC. By liquefying natural gas it shrinks in volume, making it approximately 1/580th the volume of natural gas in its original form. This makes it relatively easy to store and transport natural gas. Especially when considering that LNG, as compared to diesel, will be cheaper on the long run, it becomes an interesting option as an alternative fuel (Stroosma, 2014);(Panteia, 2013). By using LNG as alternative fuel it becomes also possible to realize emission reductions. The following reductions are realisable[7]:

- CO2 & CH4: 0%-10%[8]
- NOx: ≥70%
- PM: ~95%

CO2 is a greenhouse gas which contributes to global warming, whereas NOx and PM can be defined as air pollutants which have a negative impact on human health[9]. Concerning the abovementioned values it should be noted that the potential emission reduction applies for a single fuel installation (only LNG). The values may slightly vary for a dual-fuel installation (LNG and diesel). A dual-fuel installation is at the moment the most attractive solution, while the current LNG infrastructure is insufficient to rely solely on LNG. In case of a dual-fuel installation it will always be possible to switch over to Diesel in case the ship runs low on LNG, and there are no bunker possibilities in the surrounding environment. Due to the limited LNG infrastructure it will be risky to install a 100% LNG installation, however a single-fuel installation will be able to realize higher emission reductions (Mensch & Harmsen, 2015); (Nooijen, 2013).

Within the category of technical process eco-innovations, LNG can be defined as a cleaner technology. By installing an LNG installation the environmental performance improves through changing the conventional process of diesel driven power generation and propulsion. Therefore, using LNG as an alternative fuel makes it possible to reduce emissions already within the process and not at the end of the process or 'end-of-the-pipe' after the emissions have already been created.

[7] The average emission reduction values refer to vessels equipped with a drive train including a CCNR II diesel engine (Maierbrugger, et al., 2015).
[8] CO2 reduction of between 20%-25% but a total greenhouse gas (GHG) reduction of between 0% - 10% due to the additional emission of CH4, known as the methane slip problem (Maierbrugger, et al., 2015).
[9] Mainly air pollutants play an important role in the inland shipping sector, while the external costs of air pollution created by the inland shipping sector is relatively higher than the external costs created by their largest competitor (road transport) and the gap is widening quickly. In terms of CO2 emissions, the inland shipping sector has already a favourable position as compared to road transport (Panteia, 2013).

LNG is however a whole new concept for the inland shipping sector and currently only 5 ships run on this alternative fuel. This is a relatively small number when taking into account that the Dutch inland shipping sector consists of approximately 7000 ships (BVB, 2015); (EICB, 2015). An explanation for this low number is the fact that certain important barriers can make LNG an unattractive option. These barriers but also drivers will be discussed in section 4.1.2.

A total of 3 interviews were held with inland shipping companies that adapted the eco-innovation LNG. Two of the companies are active in the ‘wet bulk’ cargo segment, the remaining one operates in the container cargo segment. The two companies active in the ‘wet bulk’ manage a fleet consisting of 23 ships and 5 ships, respectively. Their main customers are the big oil majors (e.g. Shell and BP), traders (e.g. Vitol and Trafigura) and other companies active in the chemical industry. The company active in the container segment manages a fleet of approximately 54 ships, consisting of 4 own ships and approximately 50 charter ships. The main customers consist of shipping agents, sea shipping companies and some direct shippers.

All three companies are well aware of the current eco-innovations, the choice for LNG was therefore a conscious decision. Two of the companies directly chose for LNG, while a third company also considered another technology, but in the end it appeared that LNG was a more appropriate solution. One company is also involved in another eco-innovation, a separate ship than the LNG driven one is equipped with a SCR technology. Available subsidies for that technology played an important role, without the subsidy the company would not have equipped the ship with a SCR. The same company was also involved in a project for an inland LNG carrier, which would supply (inland) ships with LNG fuel. This project is currently on hold, mainly due to the low oil prices.

4.1.2 Determinants

In the following sections it will be discussed which determinants influenced the decision to invest in an LNG installation. As stated in the theoretical framework, these determinants are grouped into external factors, internal factors and the characteristics of the eco-innovation. These determinants will be discussed in the coming sections.

4.1.2.1 External factors

A first external driver for all three companies is public policy. All three companies received support, either in the form of subsidies or other measures, for their LNG installation, from the European

Union, national and regional government. The subsidies were a driver, while it strengthens the business case. However, all three companies explicitly state that the subsidies did not play a decisive role. One company even started with the development before subsidies became available for LNG projects.

Another form of public policy, emission norms, played a relatively more important role. The companies invested in an LNG installation partly because they wanted to be prepared for the coming legislation. This mainly concerns the new European emission norms for inland shipping, which is currently delayed but will be implemented in the short run. However, to date, it is still not clear what the exact norms will be and when it will come into effect. On the other hand, there is the Rotterdam climate initiative in sight, which will as of 2025 keep out polluting ships from the port of Rotterdam. Ships have to comply at least with the CCR-2 norm or the European Union's 2004/26/EC-directive. This is a relevant issue for the majority of the fleet, while 50% up to 80% of the Dutch fleet calls the port of Rotterdam.

Public policy can also work as a barrier. For example, it is officially not yet allowed in the inland shipping sector to use LNG as an alternative fuel. A request for exception has to be submitted to the Central Commission for the navigation of the Rhine (CCR). In addition, a request has to be submitted physically to the AND safety commission in Genève. Especially one of the companies experienced this as extremely time consuming.

The customer as determinant is an interesting case. While all three companies state that customers did not explicitly ask for more sustainable transportation. One company stated that some customers increasingly ask whether a CO2 policy is being managed and what the company does regarding sustainability initiatives. CO2 is currently important while it is globally an important issue, however it is expected that pollutant emissions (e.g. NOx and PM) will also strongly gain in importance. Thus, regarding the customer there is one important point all three companies agree about, currently there is no significant demand for more sustainable transport, however this situation will most likely change in coming years. All three companies share the vision that in the near future providers of 'greener' transportation will be able to recruit relatively more customers. Therefore they all state that they are investing in the future. This can in turn be related to other determinants, like environmental legislation which is increasingly becoming more stringent and the civil society (larger public) which is becoming increasingly more aware about the environment and the negative impact they have on it. These determinants are gaining in importance and as such positively affect the importance of 'customers' as a determinant. While the customers of inland shipping companies (e.g.

shippers), will have to react on these developments by engaging in more sustainable activities, for example by choosing for more sustainable ways of transportation for their goods.

A third driver is the competition. Even though this is a less important driver as compared to the previous ones, it still had an effect. Two of the three companies mentioned that there is serious overcapacity in the sector, this is in turn related to the internal determinant 'Characteristics of the sector.' The overcapacity drives companies to diversify itself from the severe competition. In this case this concerns diversification by investing in 'greener' solutions, in order to provide 'greener' transportation services.

Financial institutions, banks in this case, did not play a significant role in the three LNG cases. Banks are currently very reluctant in providing loans to inland shipping companies. The current economic situation and the overcapacity in the sector are import reasons for this (EICB, 2015). However, the three companies did not experience this as a barrier, while an important share was financed through subsidies and while they were in the possession of enough own financial resources. Moreover, before the major drop in oil prices in 2014, investing in an LNG installation provided a positive business case which would be enough to convince the bank in providing a loan. This shows that financial institutions as determinant is interrelated with other determinants. For example, the reluctant attitude of banks was not experienced as a barrier while amongst other thing LNG provided a positive business case due to its potential cost saving characteristic, due to the available subsidies which is in turn part of the determinant public policy and due to the financial situation of the company which may in turn be related to another internal determinant, the 'company size'. It can be argued that while these three companies are relatively large in size, they may also have relatively more financial resources at their disposition as compared to small-sized inland shipping companies, which makes it easier and more likely to invest in relatively expensive 'green' technologies like LNG.

The determinants 'availability of information', 'research centers' and 'industrial associations' played such an intertwined role that those three determinants can actually be seen as one. Branche organizations like the EICB and research centers like Panteia and Ecorys regularly work together on researches about eco-innovations (e.g. LNG) in the inland shipping sector. Furthermore, under the guidance of EICB an 'Innovation Lab' is set up. Various suppliers of 'green' technologies and end-users work together on broadly applicable 'green' technologies in the inland shipping sector. These initiatives make it possible for inland shipping companies to acquire information about such technologies in a relatively easy manner. The availability of information will make it in turn easier to weigh the pros and cons of eco-innovations and consequently to take a decision whether to adapt a particular eco-innovation. Especially one company stated that this is an important driver, also for other innovations in general, because inland shipping companies mostly do not have a separate division working on innovations. The core business consists of shipping and it is therefore difficult to reserve time for research in order to acquire information about eco-innovations.

4.1.2.2 Internal factors

As discussed above, the positive financial situation of all three companies were important drivers, while an LNG installation requires a significant investment of approximately €1.2 mln. The healthy financial situation can in turn be related to the company size. The inland shipping sector consists mainly of small and medium-sized businesses. Approximately 87% of the inland shipping companies manage 1 ship (Buckmann, et al., 2008). Therefore, given their fleet the three companies in this case can be defined as relatively large-sized inland shipping companies. It may be relatively easy for a larger company to reserve financial resources for an investment.

The company size may in turn be related to another determinant, namely the technological competency (absorption capacity) and capacity in general. It is not easy to adapt an eco-innovation like an LNG installation, while it requires a significant amount of time and effort, which will be discussed in the coming section about the characteristics of LNG. However, a relatively large company with more and specialized employees may be more competent to adapt a 'much demanding' eco-innovation like an LNG installation. For such a company it will be easier to engage in the installation of LNG, but also in the operation and maintenance. Furthermore, it will be easier to engage in the necessary collaboration and information flows, which will also be further explained in the section about the characteristics of LNG.

The environmental strategy and organizational factor can be seen as a driver. While all three companies have a proactive environmental strategy and are open to change and as such to eco-innovations. This makes it easier to invest in an eco-innovation which is unknown for the sector. Although, all three companies agree about the fact that the eco-innovation also needs to have a positive business case, while they will not invest in an eco-innovation without a payback period.

4.1.2.3 Characteristics of LNG

A crucial common driver for two of the companies was business development. This determinant is not specifically mentioned in the reviewed literature as a driver for the adaptation of eco-innovations. It might therefore be a valuable addition to the existing literature on this topic. It played a crucial role while both companies have the intention to enter the LNG market in the near future. Important to mention is that both companies are active in the wet bulk segment and it may therefore be more interesting and relatively easy to diversify towards LNG as compared to companies active in the container or dry bulk segment. The intention of both companies is either to transport LNG, develop and operate LNG bunkering facilities for sea-going and inland ships, provide consultancy services for LNG cases in the maritime sector or in order to engage in other LNG related cases in the maritime sector. Both companies realize that the LNG market is a growth market which provides serious new business opportunities (Koot, 2015). By investing in an LNG installation for their ships, both companies aim to accumulate knowledge and gain experience about LNG as fuel, the LNG-installation and the broader LNG market. Eventually, this will make it easier to successfully enter and operate in the LNG market.

A first important driver of LNG itself for the three companies, was the fact that LNG as fuel was cheaper as compared to the conventional Diesel fuel. Before the significant drop in oil prices, there was a price difference of approximately 20% between LNG and the Diesel. This price gap made it possible to earn the investment back, depending on the annual fuel consumption of the ship. In order to realize a return on the investment, the relevant ship has to consume at least 500m^3 Diesel a year. This shows that the operational profile (number of trips, power demand, fuel consumption, stream velocities, etc.) of the ship is an important determinant. While based on the operational profile of the ship, it may appear that certain eco-innovations are not economically feasible. The three ships in this case did consume more than 500m^3 of diesel per year. At that moment, investing in LNG resulted in a positive business case and therefore drove the companies to invest in it. As of today however, there is nearly no price gap anymore and no return on investment due to the low oil prices.

Next to the potential cost-savings, the initial investment costs also play an important role. As previously mentioned, the companies in this case did not experience much difficulty with financing the LNG installation. However, it appeared from interviews that this is definitely a significant barrier for inland shipping companies with a relatively weaker financial position. Especially at this moment, while there is nearly no price gap and banks will most likely be reluctant to provide loans for a project without a return on investment or with an uncertain return on investment.

The complexity and compatibility of the LNG installation were certainly important barriers for all three companies. They all state that LNG, as an alternative fuel, is a whole new phenomena for inland shipping. The technology is already being applied for years in other sectors, but not in the inland shipping sector. As result, developing suitable LNG installations for inland ships is also new for the suppliers of LNG hardware. The technology is not yet standardized for the inland shipping sector and consequently every LNG installation needs to be custom fit to each ship. This is especially an issue when an LNG installation has to be installed into an existing ship. This was the case for one of the three companies. An existing conventional inland ship is not designed for such an LNG installation, which is significantly different in size and shape from conventional diesel installations. This forms especially a problem for dry bulk and container ships. The LNG fuel tank is an important component of the overall installation, however this tank is quite large and oval. For wet bulk ships this forms not a significant problem, while it can be placed on deck. For dry bulk and container ships this tank needs to be placed in the cargo hold. First of all, this may completely be not compatible and secondly this will happen at the expense of loading capacity. Next to the tank, the engines are also relatively large which may also prove to be difficult to install into an existing ship. Next to the installation, one company stated that operating and maintaining the LNG installation also costs quite some effort, while it is a whole new concept for the crew in the ship. All three companies agree that the complexity and compatibility of an LNG installation will especially be a major barrier for the small sized inland shipping company, due to their relatively limited capability to cope with these matters.

Another common factor between all three companies was the necessity to make an investment, caused by the ending lifespan of existing ships and equipment. Two of the companies took the decision to order a new ship, whereas the third company had to replace the existing engines in one of their ships. So the opportunity or necessity to make an investment at that moment may be defined as a first driver for the eco-innovation. This can be related to the determinant 'existence of an installed base', which explains that eco-innovations will be more easily adapted if existing assets already have been depreciated. However, it can be argued that this driver is merely important for the moment of an investment and not that much for the investment itself, while a company may already have the intention to invest in a 'greener' solution, i.e. an eco-innovation in this case.

It is also stated by the interviewees that expectations of cost reductions and quality improvements act as barriers for inland shipping companies which consider investing in an LNG installation. The concept is quite new for the sector and therefore the technology has to be further developed and standardized, while much is still custom fit and this significantly drives up the price. Those companies who are interested in an LNG installation might want to wait, until the technology is being developed further and standardized, while this might lower the investment costs.

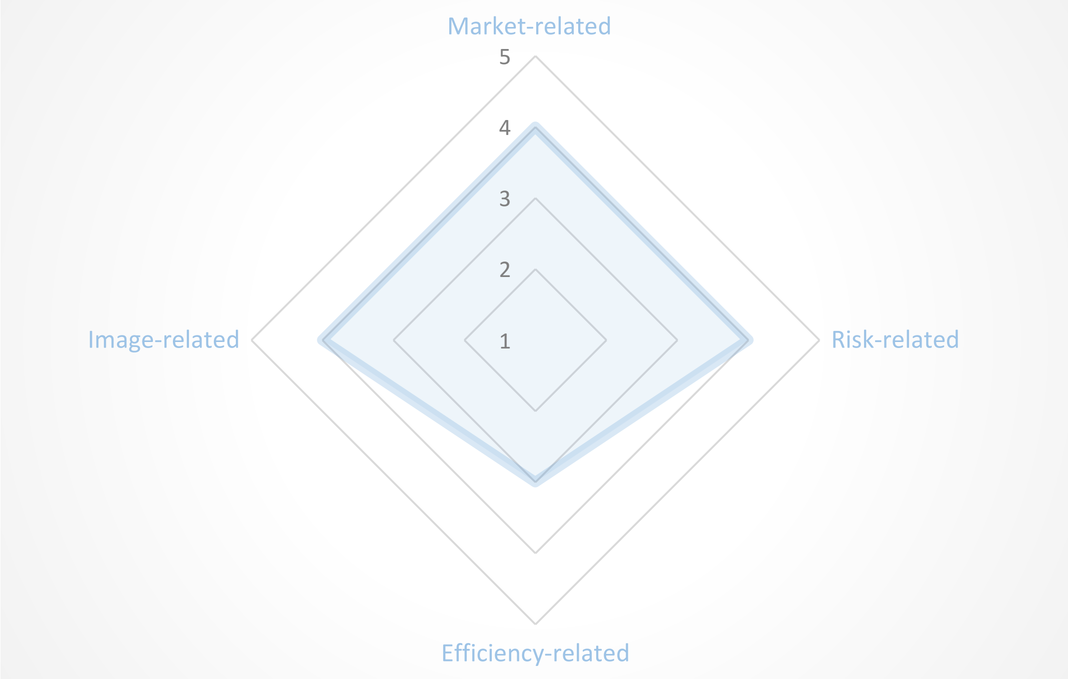
4.1.3 Effects LNG on the competitiveness

The effects on the competitiveness will be discussed according to the four competitiveness dimensions, as discussed in the theoretical framework. This concerns the market-related, image-related, efficiency-related, and risk-related competitiveness. Figure 7 on the next page summarizes and illustrates the effects on the competitiveness, which are based on the experiences of the three companies in this case.

Figure 7

Competitiveness dimensions - LNG

1: Strongly disagree
2: Disagree
3: Neutral
4: Agree
5: Strongly agree



4.1.3.1 Market-related competitiveness

Two companies are neutral about the effect of LNG on the market-related competitiveness, while a third experienced a positive effect. The two companies that agreed on the neutral effect argue that due to the overcapacity the price is a determining factor. Shippers choose for those Inland shipping companies that can offer the lowest prices and it is unlikely that an innovative ship with a significant investment will offer the lowest price. It is also stated by one of the companies that investing in one 'green' ship does not make much difference regarding the market-related competitiveness. It attracts the attention of stakeholders, but it is not like that a company gets much more sustainable in its business doing, just because of one ship.

However, both companies argue that it will certainly make a difference when there is no price differential between a 'green' and 'grey' ship. In such a situation, the shipper will definitely choose for the provider of more sustainable transport. Both companies also agree on the vision that 'green' ships will make a difference in the near future, regarding the market-related competitiveness. Especially one company strongly believes that inland shipping companies with a relatively 'green' fleet will be able to attract more customers, even in case they do not offer the lowest price. While civil society is getting more aware about the environment, and as a result shippers will have to respond to this development by transporting their goods in a more environmental way, even if this means a higher price.

A third company however, stated that they did experience a positive effect upon the market-related competitiveness. The introduction of the LNG ship provided the company extra publicity and notoriety, which is related to the image-related competitiveness and will be discussed in a later section. However, this strong boost in the image-related competitiveness caused certain shippers to approach the company for the services it provides. The interviewee stated that potential customers intentionally approach them, due to the environmental-friendly publicity and notoriety, which is in turn strongly affected in a positive way by the LNG project. This illustrates in this case that the success of the market-related competitiveness depends on the image-related competitiveness, however the two other cases discussed above show that this might not always be the case.

4.1.3.2 Image-related competitiveness

All three companies state that the eco-innovation had, and will continue to have, a positive effect on the image-related competitiveness. During the developments all companies got into contact with many parties, like suppliers, governments and customers about the LNG installation, and all parties reacted in a positive way on the eco-innovation. An LNG installation also produces significantly less noise as compared to a diesel installation. It appears that workers on board of the ship are very satisfied about the low noise level. This is relevant while 'worker satisfaction' is also an indication for image-related competitiveness.

However, it appeared that the degree of impact on the image-related competitiveness, does vary among the three different companies. Not every company got for example as much media attention and attended as much conferences and meetings, due to the eco-innovation, as compared to the other one. This can be related to certain factors, under which the capacity/ability and motivation to bring the eco-innovation to the attention of relevant stakeholders. One company for e.g. worked on a serious media plan to place the eco-innovation and the company in the spotlight. This plan worked and the company got a lot of media attention and attended a lot of meetings and conferences. Moreover, the owner of the company even received the price 'Havenman van het jaar 2011'. Every year this prestigious title is being given to a person with a prominent contribution to the development of the port of Rotterdam (havenman, 2015).

Company size might be another factor which could determine the degree of impact upon the image-related competitiveness. One of the companies is relatively large is size and has a relatively large customer base. For such a large company it may be relatively easy to reach the masses, in order to promote its 'green' ship and the broader environmental strategy of the company. This might in turn have a relatively stronger positive effect upon the image-related competitiveness.

4.1.3.3 Efficiency-related competitiveness

Two companies are neutral about the effect of LNG on the efficiency-related competitiveness. These companies state that due to the current low oil prices there is nearly no price gap anymore between LNG and diesel. As result, it is currently not really possible to save on fuel costs and consequently there is almost no return on investment. No statement is being made about the maintenance costs. These costs might be lower as compared to conventional diesel installation, however this has yet to appear.

One company experienced a positive effect on the efficiency related competitiveness. This is also the company that invested as first in an LNG driven ship, which became operational in 2011. However, the interviewee stated that this positive effect was experienced before the major drop in oil prices that occurred in 2014. Before the major drop in oil prices the company was able to realize a saving of approximately 25% to 30% on fuel costs. Since the drop in oil prices in 2014 though, no savings are realized on fuel costs.

All three companies state that the current low oil price worsens the business case for LNG. A return on investment is not possible, however all three companies state that they do not see this as a major problem. “LNG is a commodity, just like oil, and the prices may fluctuate over time which may in turn affect the business case either in a positive or negative way. It is a risk we have to live with.” The interviewees expect that the oil price will increase again in the long run, which might in turn positively affect the business case for LNG.

4.1.3.4 Risk-related competitiveness

All three companies state that LNG has a positive effect on the risk-related competitiveness. In other words, by using LNG as alternative fuel for diesel it is absolutely possible to comply with the current, and most likely also the future emission norms. All three parties state that the coming European emission norm is a big question mark, while its details and date of entry are still not known. However, due to its good performance in terms of emission reduction, they all expect that it will be possible for LNG driven vessels to comply with the coming norms.

4.1.4 Sustained competitiveness

It appeared that LNG has a positive effect on the competitiveness of an inland shipping company. In order to sustain these advantages in the long run, an eco-innovation has to be non-substitutable for the company adapting it and inimitable for the competitor. Based on the operational profile of the ship, an LNG installation might be the most suitable ‘greening’ solution for the relevant ships of the three companies in this case. However, this does not mean that it was absolutely a non-substitutable ‘greening’ solution, while a wide range of other, perhaps less suitable, ‘greening’ solutions is available.

Regarding the inimitability it can be stated that an LNG installation is being provided by different market parties. Every inland shipping company is free to acquire such an installation, so in that sense it is not inimitable. One of the interviewees even stated that they stimulate other inland shipping companies to consider 'green' technologies, including LNG. The underlying thought is that a broad roll-out of eco-innovations in the inland shipping sector will improve the performance of the whole sector in terms of sustainability. This will in turn make the modality more attractive for shippers and more shippers may consider inland shipping for the transportation of their goods. "This will create more work for everyone, and hopefully also for us." However, even though the eco-innovation is not inimitable, it is currently characterized by significant barriers, and according to the interviewees these barriers might be too high for small sized companies to deal with. It can therefore be argued that before any further developments and standardization of the technique, i.e. in the short-run, companies might be able to sustain the positive effects on the competitiveness, unless the same positive effects can be realized with other eco-innovations.

4.1.5 Conclusion

Table 11 shortly summarizes the results of the case on LNG. It appeared that the decision to invest in LNG is influenced by various determinants which are highly intertwined. The availability of subsidies and the cost-saving characteristic of an eco-innovation for example may have a positive effect on the willingness of banks to provide a loan. This example illustrates that determinants from different categories may either strengthen each other as driver, or the other way around as barrier. A determinant can also work both as a driver and barrier, which is the case with public policy. It appears that the characteristics of LNG had in general the strongest influence on the decision to invest in an LNG installation.

The three cases showed that LNG had a positive effect on the competitiveness of the three inland shipping companies. However, the degree of this effect varies per competitiveness dimension and per company. In general, the image- and risk-related competitiveness dimensions experienced the strongest positive effect. The effect on the efficiency-related competitiveness dimension is currently very limited due to the almost non-existent price gap between LNG and diesel. Depending on this price gap, this effect may become more positive or negative in coming years. The market-related competitiveness dimension experienced a minor positive effect. Only one company stated that LNG had a positive effect on it.

It also appeared that the different competitiveness dimensions are interrelated. Image-related competitiveness might positively affect the market-related competitiveness. It also appeared that the degree of impact depends on the company itself. A relatively large company with a broad customer base, which strongly puts effort in bringing the eco-innovation and the broader environmental strategy to the attention of relevant stakeholders, might be more able to realize a positive effect on the market-related competitiveness.

It is difficult to state that LNG will have a sustainable positive effect on the competitiveness, while the eco-innovation cannot be defined as non-substitutable for the company adapting it and inimitable for the competitor. The technology is however characterized by significant barriers and it may therefore be stated that the competitive advantages may be sustained in the short-run, until these barriers are lowered through further developments and standardization.

Table 11: Results LNG

DETERMINANTS		
EXTERNAL *Important role* Relevant determinants: *- Public policy* *- Customers* *- Competition* *- Availability of info* *- Research centres* *- Industrial associations*	**INTERNAL** *Important role* Relevant determinants: *- Financial situation* *- Company size* *- Technological competency (absorption capacity)* *- Environmental strategy & organizational factors*	**CHARACTERISTICS** *Very important role* Relevant determinants: *- Business development* *- Costs and cost-savings* *- Complexity & compatibility with existing systems* *- Existence of an installed base*

COMPETITIVENESS DIMENSIONS			
MARKET 2*Neutral + 1*Agree	**IMAGE** 2*Strongly Agree + 1*Agree	**EFFICIENCY** 2*Neutral + 1*Agree	**RISK** 2*Agree + 1*Strongly Agree

SUSTAINED COMPETITIVENESS	
NON-SUBSTITUTABILITY Does not meet the requirement	**INIMITABILITY** Meets the requirement only in the short run

4.2 SCR&DPF

4.2.1 Introduction

Within the category of diesel after-treatment systems, selective catalytic reduction (SCR) and diesel particulate filters (DPF) are identified as the two promising eco-innovations. These eco-innovations put the focus mainly on reducing air pollution. SCR is a technology applied on diesel engines which aim to reduce NOx emissions, whereas DPF is a technology installed in exhaust systems to cut PM emissions. Approximately 70 ships have an installed SCR or DPF, or both. These two technologies are often installed together and realize the following emission reductions[10]:

- NOx: 80-90%
- PM: ~90%

It can be seen that the after-treatment technologies are mainly meant to reduce pollutant emissions. The technologies do not result in any efficiency gains, consequently there occurs no reduction in fuel consumption and CO2 emissions. Moreover, SCR and DPF may even slightly improve the operational costs which will be discussed in subchapter 4.2.3.3 (Maierbrugger, et al., 2015); (Panteia, 2013).

SCR's and DPF's are basically component additions to the engine, and aim to reduce pollutant emissions after they have been created without really altering the process of power generation and propulsion. They therefore only bring some incremental changes to the existing process. Given these characteristics they can be defined as end-of-pipe technologies.

A total of 3 interviews were held with inland shipping companies that adapted a SCR&DPF installation. All three companies manage only one ship. One company is active in the 'wet bulk' segment, with the oil majors (e.g. Shell and BP) as customers. A second company belongs to the cooperation NPRC, is active in the 'dry bulk' segment and has a long-term contract with AkzoNobel for the transportation of industrial salt. A third company is active in both the 'dry bulk' and container segments and has a very broad and diverse customer base.

The interviewees stated that they are well aware about the current eco-innovations in the sector. They state that the developments are closely followed, while it a very relevant subject for them. Two of the companies are only involved in a SCR&DPF installation. One company is also involved in other

[10] The average emission reduction values refer to vessels equipped with a drive train including a CCNR II diesel engine.

initiatives, for example in the development of the COVADEM program. The same company also developed a calculator tool in cooperation with Capgemini and Connekt, in order to calculate emissions per container per trip, and the company also participated in the VVB program.

4.2.2 Determinants

In the following sections it will be discussed which determinants influenced the decision to invest in a SCR&DPF installation. As stated in the theoretical framework, these determinants are grouped into external factors, internal factors and the characteristics of the eco-innovation. These determinants will be discussed in the coming sections.

4.2.2.1 External factors

A common and important external factor among all three companies was public policy. All three companies wanted to be prepared for the coming European emission norm and the Rotterdam climate initiative. The Rotterdam climate initiative was especially important for the company active in the 'wet bulk' segment, while its activities are mostly in the port area of Rotterdam.

Next to the emission norms, public policy in the form of subsidies was also a very important driver. All three companies received subsidies in order to finance the SCR&DPF installation, which significantly lowered the financial barrier. One company even stated that they probably would not have done it without subsidies. A point of attention is that this company adapted the eco-innovation after the beginning of the economic crisis in 2009, as compared to the other two that adapted the installation before the crisis. In the time period after 2009 the economic climate in the sector was, and still is, very miserable. There is less demand for inland shipping, the sector has to cope with severe overcapacity and banks are not willing to provide loans to inland shipping companies. As result of these developments it became more difficult for an inland shipping company to invest in an eco-innovation. It can therefore be stated that subsidies may now play a relatively more important role as driver, due to the economic climate in the sector which is currently a barrier for the uptake eco-innovations.

The customer played especially an important role as driver in one of the cases. In one case AkzoNobel approached the inland shipping company, and 5 other companies which all belong to the cooperation NPRC, with the request for 'greener' transportation. AkzoNobel was prepared to finance an important part of the installation which would contribute to this objective. In addition, a long-term contract would be signed with the inland shipping companies for the transportation of salt. The customer did not play such a decisive role in the remaining two cases. The interviewees in these cases stated that they did it merely with the customer in mind. The company active in the 'wet bulk' segment stated that his customers, the oil majors, are strongly involved in sustainability initiatives. The interviewee stated that it is not wise to stay behind these developments as a contractor, even if the customer does not explicitly asks for more sustainable transportation for their products. Moreover, it is stated that the customer will always choose for the company that can offer the lowest prices. However, in a situation of equal prices a 'green' ship will be preferred and both interviewees expect that in the near future the demand for more sustainable ways of transportation will increase and that they want to be prepared for it. The expectation of increased demand for more sustainable transportation is related by the interviewees to increased environmental awareness in the society and the expected economic recovery. Both developments will make it more attractive for shippers to choose for 'green' ships as compared to 'cheap' and 'polluting' ships for the transportation of their goods.

The fierce competition in the overall sector played also a role. One interviewee explicitly stated that they wanted to differentiate itself from the competition by installing a SCR&DPF, in order to be able to provide 'greener' transportation services, while this might make it more easy to attract customers.

The availability of information played also, although to a lesser extent, a role. One company for example participates in the Innovation Lab as end-user. As result, the interviewee states that he is well aware of the most suitable 'greening' solutions for his ship, which made it relatively easy to weigh the pros and cons of a SCR&DPF installation. However, it should be noted that the technology is quite mature and acquiring sufficient information is not an issue while this is widely available.

4.2.2.2 Internal factors

The financial situation did not play such an important role for all three companies while an important part was already financed through subsidies and in one case even by the customer. The characteristics of the sector did play a role. As mentioned before, the sector is characterized by severe overcapacity which drives up the competition and drives inland shipping companies to diversify itself from competitors. The technique of an SCR&DPF installation is not as complex as for example an LNG installation. It is a quite mature and proven technology, consequently the technological competency (absorption capacity) nor the company size did play a notable role as determinant.

The environmental strategy definitely played a role as driver. For example, one interviewee stated: "A transition towards a more sustainable economy is necessary for the good of all." In his opinion everyone should contribute to this in his or her own way and the company did this by investing in a SCR&DPF installation in order to cut emissions.

4.2.2.3 Characteristics of SCR&DPF

The costs of a SCR&DPF installation was not experienced as a major barrier, while an important part was already subsidized and in one case even partly financed by the customer. In addition, a SCR&DPF installation requires a relatively lower investment as compared to LNG. The investment cost depends on the engine capacity but one interviewee stated that €250k is a good reference point. Like most other end-of-pipe technologies, a SCR&DPF installation has no cost-saving characteristic and therefore no return on investment. As mentioned before, it is also a quite proven and mature technology and therefore no interviewee experienced it as complex or incompatible. However, they did state that it might be a problem in terms of compatibility for relatively small ships. Small inland ships may have limited available space in the engine room and consequently a SCR&DPF installation may not fit.

The determinant 'complementary innovations' played a role for one of the companies. This determinant states that existing complementary eco-innovations in the firm will facilitate the uptake of other eco-innovations. One of the companies is also involved in other complementary eco-innovations, for example in energy efficient navigation. The involvement in such complementary eco-innovations contributed to the uptake of other eco-innovations.

The determinant 'installed base' was relevant for two of the companies. As explained before, this determinant state that eco-innovations will be more easily adapted if existing assets already have been depreciated. One of those companies had to invest in a new ship, due to an ending lifespan of the existing ship. The interviewee stated that this provided an opportunity to equip the new ship with a 'green' technology. So, in this case the installed base worked as a driver. In the other case, the installed base worked as a driver for the SCR&DPF installation but as a barrier for other 'green' solutions. The interviewee stated that the ship and everything installed in it were relatively new. It was therefore no option to invest in an LNG installation or hybrid propulsion. These installations are relatively expensive and would replace existing equipment in the ship which was not depreciated yet, while on the other hand a SCR&DPF installation is an add-on solution and does not replace any existing equipment in the ship.

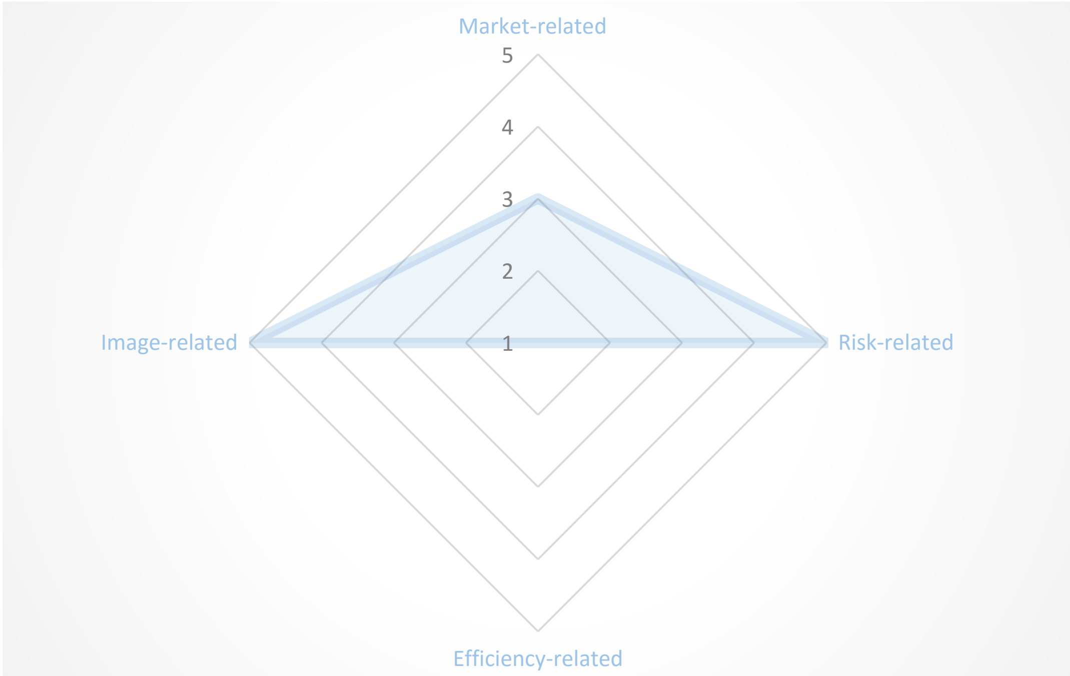
4.2.3 Effects SCR&DPF on the competitiveness

The effects on the competitiveness will be discussed according to the four competitiveness dimensions, as discussed in the theoretical framework. This concerns the market-related, image-related, efficiency-related, and risk-related competitiveness. Figure 9 on the next page summarizes and illustrates the effects on the competitiveness, which are based on the experiences of the three companies in this case.

Figure 9

Competitiveness dimensions – SCR&DPF

1: Strongly disagree
2: Disagree
3: Neutral
4: Agree
5: Strongly agree



4.2.3.1 Market-related competitiveness

Two companies state that the eco-innovation did not have a positive effect on the market-related competitiveness, including the inland shipping company that adapted this eco-innovation in cooperation with its customer. Both interviewees state that the price is currently a decisive determinant for shippers, due to the economic crisis, and not sustainability. The company that arranged a long-term contract with its customer as result of this eco-innovation stated that he already had enough cargo to transport.

This can be related to the fact that this company belongs to the cooperation NPRC. As member of a cooperation there is always more certainty for an inland shipping company regarding revenues and cargo, because much of the cargo is arranged for through contracts (Quispel et al., 2015). Within the inland shipping sector the shipping company has namely two options; providing its services in the spot-market or contract-market. The contract-market provides relatively more certainty for the inland shipping company. This also appears from a research in which it is stated that inland shipping companies active in the spot-market cope relatively more often with financial difficulties as compared to companies active in the contract-market (Overweel & van der Zeijden, 2014).

Coming back to the inland shipping company in this case, this company already had a contract with the customer and as such also enough cargo to transport. The interviewee stated that the only effect the innovation had was a contract for the longer term and does not view this as a positive effect on the market-related competitiveness.

The remaining third company however, takes a more neutral stand regarding the statement. The interviewee stated that with equal prices a shipper will probably choose for the ‘greenest’ ship. In the past six years the company had for example enough cargo to transport. But the interviewee stated that It is difficult to trace back whether this is due to the fact that the company has a ‘green’ ship or due to the fact it was each time by chance slightly cheaper as compared to the competitor on the spot-market. It is difficult to trace back the real reason behind it, while most inland shipping companies have no direct contact with the shipper, in most cases cargo is arranged through an intermediary, also called a ‘bevrachtingskantoor.’

It is however expected by the interviewee that in the near future shippers will consciously choose for more sustainable transportation, due to an expected economic recovery and civil society which is getting environmentally more aware. This means that investing in ‘green’ technologies now, will show its benefits in the near future.

4.2.3.2 Image-related competitiveness

Two companies agree with the statement that a SCR&DPF installation had a positive effect on the image-related competitiveness. The company that adapted this installation in cooperation with its shipper stated that it was mainly a positive image boost for the shipper. The shipper received a significant amount of positive media attention, but this had also a positive effect on the cooperation and the inland shipping company itself. The other company strongly agrees with the statement while it was one of the first companies to adapt such an installation. As result, the company received a lot of media attention and attended several meetings about sustainability in the sector. The interviewee stated that this enabled him to create new relations with potential customers. However, the interviewee also stated that the degree of effect on the image-related competitiveness strongly depends on the company itself. The company should search for opportunities to bring the eco-innovation to the attention of relevant stakeholders. This may also explain the negative stand of the third company regarding the statement. The interviewee of the third company stated that they did not experience any positive effect upon the image-related competitiveness. No positive reactions were received from relevant stakeholders, nor did the company receive any media attention as result of the eco-innovation. This may partly be due to the company itself, while it might have not put enough effort in promoting the eco-innovation.

4.2.3.3 Efficiency-related competitiveness

All three companies agree on the fact that a SCR&DPF installation has no positive effect on the efficiency related competitiveness. As an end-of-pipe technology, this installation has no cost-saving characteristic and consequently also no return on investment. Moreover, the installation even slightly improves the operational costs, while the working of a SCR requires the additional injection of urea. However, it appears that the increase in costs due to the additional urea consumption is very limited and therefore neglectable.

4.2.3.4 Risk-related competitiveness

Two of the companies strongly agree with the statement and argue that they already comply with the current emission norms and will most likely also comply with the coming emission norms. A third company is more neutral about the statement. The interviewee stated that the ship had already a very clean engine and therefore complied with existing emission norms before the installation of the SCR&DPF. Thus, the installation did not directly contribute to the risk-related competitiveness.

However, the installation will most likely have a positive effect when new emission norms will be implemented.

4.2.4 Sustained competitiveness

A SCR&DPF installation will not contribute to sustained competitiveness, while this installation does not meet the requirements of non-substitutability and inimitability. Based on the operational profile of the ship, a SCR&DPF installation might be the most appropriate 'greening' solution. However, there is a wide range of other alternative 'green technologies' and it is therefore not non-substitutable for the company adapting it. A SCR&DPF installation is also a proven and mature technology widely available in the market and not characterized by all too many barriers. It is therefore absolutely not inimitable for competitors, moreover approximately 70 ships have already a SCR or DPF on board.

4.2.5 Conclusion

Table 12 shortly summarizes the results of the case on SCR&DPF. It seems that among the three different determinant categories, external factors played the most important role. Within this category it was in general mainly public policy which drove companies to invest in a SCR&DPF installation, both in the form of emission norms and subsidies. In one case the customer played an important role. Furthermore, the discussed determinants of a SCR&DPF installation are, just like the determinants for LNG, intertwined and may either strengthen or weaken each other.

The three cases show that a SCR&DPF installation had a positive, although limited, effect on the competitiveness of the three companies. The effect varies per competitiveness dimension and per company. In general, the image- and risk-related competitiveness experienced the strongest effects. There is nearly no effect on the market-related competitiveness, it is however expected that this effect will increase in the near future. No positive effect on the efficiency-related competitiveness is realized, while a SCR&DPF installation has, like most other end-of-pipe technologies, no cost-saving characteristic.

It will not be possible for an inland shipping company to sustain the created competitive advantages, while a SCR&DPF installation does not meet the requirements of non-substitutability and inimitability.

Table 12: Results SCR&DPF

<table>
<tr><th colspan="12">DETERMINANTS</th></tr>
<tr><td colspan="4">EXTERNAL
Very important role

Relevant determinants:
- Public policy
- Economic climate
- Customers
- Competition
- Availability of info</td><td colspan="4">INTERNAL
Modest role

Relevant determinants:
- Characteristics of the sector
- Environmental strategy & organizational factors</td><td colspan="4">CHARACTERISTICS
Important role

Relevant determinants:
- Costs
- Compatibility with existing systems
- Complementary innovations
- Existence of an installed base</td></tr>
<tr><th colspan="12">COMPETITIVENESS DIMENSIONS</th></tr>
<tr><td colspan="3">MARKET

1*Neutral +
2*Disagree</td><td colspan="3">IMAGE

1*Strongly Agree +
1*Agree + 1*Disagree</td><td colspan="3">EFFICIENCY

3*Strongly Disagree</td><td colspan="3">RISK

2*Strongly Agree +
1*Neutral</td></tr>
<tr><th colspan="12">SUSTAINED COMPETITIVENESS</th></tr>
<tr><td colspan="6">NON-SUBSTITUTABILITY

Does not meet the requirement</td><td colspan="6">INIMITABILITY

Does not meet the requirement</td></tr>
</table>

4.3 Hybrid propulsion

4.3.1 Introduction

Inland ships are often equipped with excess power. The installed engines are designed for worst circumstances; sailing fully loaded, against wind and/or current. However, these circumstances are only encountered about 10% of the time. This results in considerably under-loaded engines, in turn leading to inefficiency and increased fouling (Panteia, 2013).

Right-sizing and hybrid propulsion are two different but very closely related eco-innovations. Both technologies are meant to deal with the abovementioned problem of excess power. The concept of right-sizing is basically the implementation of a 'right-sized' engine with the optimum combination of power/torque delivery, in line with the operating characteristics of the ship. This 'right-sized' engine does not necessarily have to be a ship engine. Industrial engines or marinised truck engines might also be applicable[11]. Hybrid propulsion on the other hand concerns propulsion installations which use two or more power sources. A diesel-electric installation is a commonly used hybrid concept. Such hybrid installations make it possible to switch off one of the power sources (electric or diesel) during sailing circumstances that do not require much power.

At the moment there are approximately 17 ships with a hybrid installation or a 'right-sized' engine. Almost all of these ships have a hybrid installation, there is only one known case of right-sizing and this concerns a hopper dredger which is not a suitable case for this study. By adapting one of the two eco-innovations the ship will only be equipped with the necessary engine power. This keeps the engines at their optimum operating conditions as compared to the excess power situation where the engines run far below their optimum load point. In turn, this significantly reduces the fuel consumption and consequently reduces also emissions. The following emission reductions can be realized[12]:

- CO_2 & CH_4: 0-10%
- NO_x: 0-10%
- PM: 0-10%

[11] Volvo Penta is an example of a company which is working on the marinisation of euro6 truck engines. Replacing a CCR2 ship engine with an euro6 truck engine will make it possible to realize significant emission reductions (Vissers, 2014).

[12] The average emission reduction values refer to vessels equipped with a drive train including a CCNR II diesel engine. Measures which lead to a reduction in energy (fuel) consumption show a proportional CO2 reduction. NOx emissions are generally more or less linear proportional with CO2 emissions in kg, while PM will probably be reduced somewhat less than proportional. As a first guess, it may be assumed that the total PM and NOx emissions in kg are reduced by the same percentage as the total CO2 emissions and fuel consumption in kg (Maierbrugger, et al., 2015).

Both eco-innovations can be defined as cleaner technologies while they adjust the process of power generation and propulsion, making it possible to realize efficiency gains and reduce emissions before they have been created (Maierbrugger, et al., 2015).

A total of two interviews are conducted with inland shipping companies that adapted a hybrid propulsion installation as eco-innovation. One of the companies owns 2 ships, whereas the other manages a fleet consisting of 3 ships. The first company is active in the 'dry bulk' segment and navigates for various customers. The second company is active in the container segment and is at the service of Multimodaal Container Services (MCS).

Both companies are well aware of the current eco-innovations in the sector. Before the hybrid propulsion installation, both companies considered an LNG installation. However, LNG appeared to be not feasible due to the discussed barriers of LNG in combination with the operational profile of the ships. Next to the hybrid propulsion, both companies are also involved in other eco-innovations. One of the companies has also a SCR&DPF installation in the same ship as with the hybrid propulsion installation. The other company has installed a SCR&DPF installation into their second ships and will equip a third ship also with a hybrid propulsion installation. Furthermore, the ship with the current hybrid propulsion was initially built with an innovative energy-efficient design and is in addition equipped with many 'smart tools.'

4.3.2 Determinants

In the following sections it will be discussed which determinants influenced the decision to invest in a hybrid propulsion installation. As stated in the theoretical framework, these determinants are grouped into external factors, internal factors and the characteristics of the eco-innovation. These determinants will be discussed in the coming sections.

4.3.2.1 External factors

Public policy, especially the coming emission norms, played for both parties a role. Both companies stated that they want to be prepared for the future, in order to comply with new emission norms. One company even strongly believes that the government will implement 'the polluter pays principle' in the near future. Fines could be imposed to inland shipping companies based on real-time monitoring of a ship's emissions. The interviewee related this possible scenario to the strong political trend towards an environmental friendly and sustainable economy.

The subsidies played a minimal role, one of the companies state that the decision to invest should not depend on subsidies, while an eco-innovation should have a feasible return on investment without subsidies. Certainly, subsidies strengthen the business case, but should not play a decisive role as driver.

In addition to the government two external actors played a very important role as driver, namely the supplier and the customer. The supplier of ship parts played a major role for one of the companies. It appeared that the company was approached by its supplier of ship parts before the construction of the ship, for the possible installation of a hybrid propulsion.

The customer played an important role as driver for the other company. The customer, a logistics service provider, of the inland shipping company serves relatively large-sized shippers, under which FrieslandCampina, and noticed that his customers increasingly move towards more sustainable business processes. Consequently, at the request of FrieslandCampina the logistics service provider worked with the inland shipping company in this case, on ways to provide ‘greener’ transportation services for FrieslandCampina. Eventually the most feasible solution appeared to be a hybrid propulsion.

Other external factors also played a role, even though to a lesser extent. One company stated for example that the miserable economic climate during the investment played a minor role as barrier, while investing in uncertain economic times may bring extra risks. The other company indicated ,based on his own experience, that the current bad economic situation is a major barrier for many other inland shipping companies. It is stated by the interviewee that many companies are barely able to “hold their head above water” and are consequently not able to spend time, effort and financial resources on eco-innovations.

4.3.2.2 Internal factors

No factors within this category hindered the decision to invest in a hybrid propulsion. On the other hand, these factors played in general also a less important role as driver. The environmental strategy and other organizational factors of both firms were the most important internal driver. This played especially an important role for the company which is working on a second hybrid propulsion for its third ship. The company is exceptionally interested in and open for different forms of innovation. This proved to be an important internal drive for the eco-innovation.

The same interviewee also stated that the traditional and conservative culture in the overall sector, which actually belongs to the internal determinant mentioned above, is a major barrier for the uptake of eco-innovations and innovations in general. According to his experience, many inland shipping companies do not invest in innovations, simply because they are not open for change and consequently the interviewee states: “unknown makes unloved.” It appears that many owners of small-sized inland shipping companies continue “blindly and without any vision” with the business model once set up by their predecessors.

4.3.2.3 Characteristics of hybrid propulsion

The cost of the installation and its cost-saving characteristic were major drivers for both companies. Both companies stated that a hybrid propulsion is an ‘affordable greening solution’ and relatively easy to integrate as compared to LNG. Both companies initially considered LNG as a ‘greening solution,’ however given the operational profile of the ships it appeared that LNG would not be a feasible option, mainly due to the insufficient annual fuel consumption below $500m^3$. Both companies would be unable to earn the investment back. Based on the operational profile of the ships it appeared that a hybrid propulsion would be the most suitable eco-innovation.

The determinant ‘installed base’ was especially relevant for one of the companies. The hybrid propulsion was installed during the construction of the ship. As such, there was an opportunity to invest in an eco-innovation. But as mentioned earlier, it can be argued that this driver is merely important for the moment of an investment and not that much for the investment itself, while a company may already have the intention to invest in an eco-innovation.

The determinant ‘complementary innovations’ played a role for one of the companies. This company was already involved in other complementary eco-innovations, like an innovative energy-efficient ship design and a SCR&DPF installation. The involvement in such eco-innovations may have contributed to the uptake of other eco-innovations.

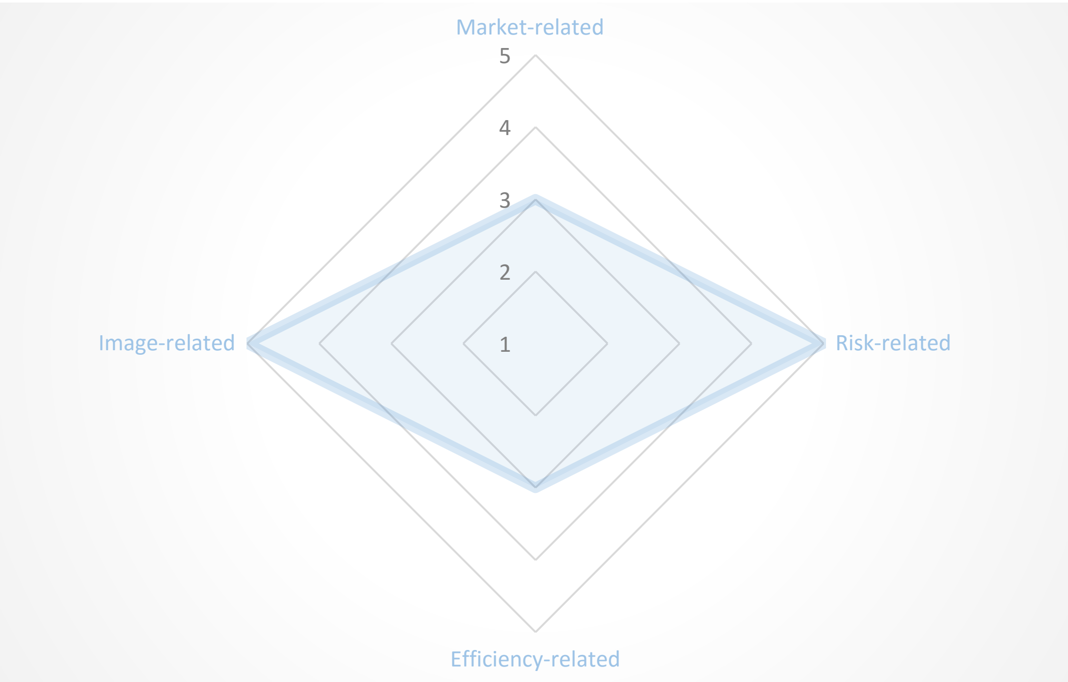
4.3.3 Effects hybrid propulsion on the competitiveness

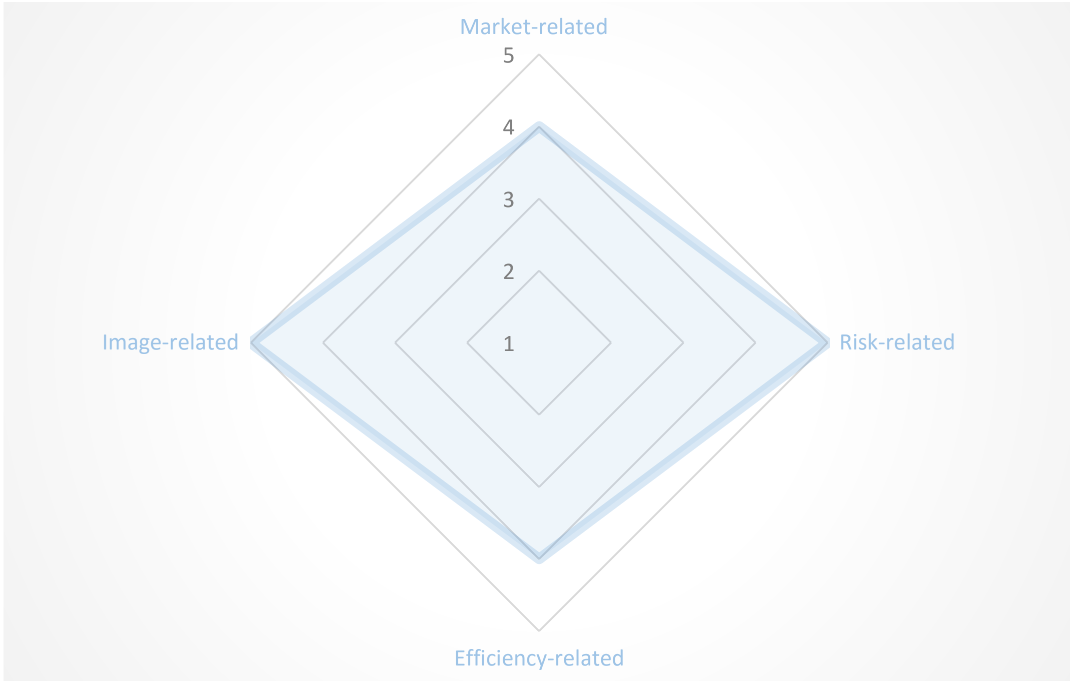
The effects on the competitiveness will be discussed according to the four competitiveness dimensions, as discussed in the theoretical framework. This concerns the market-related, image-related, efficiency-related, and risk-related competitiveness. Figure 11 on the next page summarizes and illustrates the effects on the competitiveness, which are based on the experiences of the two companies in this case.

Figure 11

Competitiveness dimensions – Hybrid propulsion

1: Strongly disagree
2: Disagree
3: Neutral
4: Agree
5: Strongly agree





4.3.3.1 Market-related competitiveness

One company is very neutral about the statement. The interviewee stated that they invested in this eco-innovation partly with the customer in mind and the expectation that it will have an effect on the market-related competitiveness. So far, no effect has been realized but it is strongly expected that this will change in the near future, caused by an economic recovery and shippers which will get even more environmental conscious in their business processes. This might provide opportunities in the future to recruit more customers and increase cargo.

The other company however states that the eco-innovation had a positive effect on the market-related competitiveness, while it provides new opportunities. Several potential customers approached the inland shipping company for negotiations, however the company has a long-term contract with its current customer and it is therefore not possible to ship for other customers.

4.3.3.2 Image-related competitiveness

Both interviewees agree with the statement and experienced a strong effect on the image-related competitiveness, especially while they were one of the first inland shipping companies to invest in a hybrid propulsion for their ship. The government, customers and other stakeholders reacted in a very positive manner as result of the eco-innovation. The eco-innovations received also significant media attention due to the fact that two relatively large-sized shippers (Cargill and FrieslandCampina) made use of the services of the two inland shipping companies in this case.

Especially one of the interviewees stated that he is still being approached by many stakeholders in order to give interviews about the subject and attend relevant meetings. It also appears, partly based on the quantity of media-attention and attended relevant meetings, that the effect on the image-related competitiveness is relatively greater for this company as compared to the other one. This may also partly explain the difference concerning the market-related competitiveness between both companies. The company that experienced a positive effect on the market-related competitiveness is namely also the company that experienced a relatively greater positive effect on the image-related competitiveness. In turn, the difference in degree of impact on the image-related competitiveness can be explained by different factors, under which the ability and motivation to bring the eco-innovation to the attention of relevant stakeholders.

4.3.3.3 Efficiency-related competitiveness

One of the companies takes a neutral stand concerning the statement. Despite the fact that savings of approximately 12.5% on fuel consumption are realized, the interviewee states that this is not enough for a feasible return on investment. The other company is positive about the statement, it realized savings of approximately 15% on fuel consumption and expects a return on investment within 7 or 8 years depending on the fuel price. The interviewee expects that the oil price will increase in the short run, which will positively affect the return on investment. It is also being stated that maintenance costs are much lower. Thanks to the hybrid installation the engine runs 'cleaner' in turn requiring less maintenance.

However, the interviewee also states that the ship was initially built with a very energy-efficient design and is in addition equipped with many 'smart tools', all contributing to the efficiency-related competitiveness. This makes it difficult to purely look at the effect of the hybrid installation on the efficiency-related competitiveness.

4.3.3.4 Risk-related competitiveness

Both companies strongly agree with the statement, they already comply with the current emission norms and expect also to comply with the coming emission norms, despite the fact that it is not yet known how these norms will look like. Especially the company with the hybrid propulsion in combination with the SCR&DPF installation is highly confident, while the interviewee states that his ship is currently one of the 'cleanest' ships in the Dutch fleet.

4.3.4 Sustained competitiveness

It is unlikely that a company will realize sustained competitiveness by installing a hybrid propulsion, while this eco-innovation does not meet the requirements of non-substitutability and inimitability. As was the case with the other eco-innovations, a hybrid propulsion might be the most appropriate solution for both ships, however there is a wide range of other alternative 'green technologies' and it is therefore not non-substitutable for the company adapting it. A hybrid propulsion is also a proven and mature technology widely available in the market. All other competitors are able to acquire a hybrid propulsion for their ship(s) and it is therefore not an inimitable eco-innovation.

4.3.5 Conclusion

Table 13 shortly summarizes the results of the case on Hybrid propulsion. Among the three determinant categories external factors had the strongest influence on the decision of both companies to invest in a hybrid propulsion. Public policy, customers and suppliers played the most important role within this category. Internal factors and the characteristics of the eco-innovation had as compared to external factors less influence. Also with these two cases it appeared that determinants are intertwined with each other.

The two cases show that a hybrid propulsion has a positive effect on the competitiveness of an inland shipping company. The degree of effect varies however per competitiveness dimension and per company. In one case a positive effect was realized on the market-related competitiveness, whereas this was not the case for the other company. This also applies for the efficiency-related competitiveness. Both companies realized savings on fuel costs, however this results only in one case in a feasible return on investment. Both interviewees strongly agreed with the positive effect on the image- and risk-related competitiveness. Although, it seems that one company realized a relatively greater positive effect on the image-related competitiveness as compared to the other one. It also appears for this specific case that the image-related competitiveness positively affects the market-related competitiveness. This relationship between the two competitiveness dimensions was also found for the companies that adapted an LNG installation.

A hybrid propulsion as eco-innovation will not contribute to sustained competitiveness for the company adapting it, while this eco-innovation does not meet the necessary requirements of non-substitutability and inimitability.

Table 13: Results Hybrid propulsion

<table>
<tr><th colspan="12">DETERMINANTS</th></tr>
<tr>
<td colspan="4">EXTERNAL
Very important role

Relevant determinants:
- Public policy
- Customers
- Suppliers
- Economic climate</td>
<td colspan="4">INTERNAL
Modest role

Relevant determinants:
- Environmental strategy & organizational factors</td>
<td colspan="4">CHARACTERISTICS
Important role

Relevant determinants:
- Costs and cost-savings
- Compatibility with existing systems
- Complementary innovations
- Existence of an installed base</td>
</tr>
<tr><th colspan="12">COMPETITIVENESS DIMENSIONS</th></tr>
<tr>
<td colspan="3">MARKET

1*Neutral +
1*Agree</td>
<td colspan="3">IMAGE

2*Strongly Agree</td>
<td colspan="3">EFFICIENCY

1*Neutral +
1*Agree</td>
<td colspan="3">RISK

2*Strongly Agree</td>
</tr>
<tr><th colspan="12">SUSTAINED COMPETITIVENESS</th></tr>
<tr>
<td colspan="6">NON-SUBSTITUTABILITY

Does not meet the requirement</td>
<td colspan="6">INIMITABILITY

Does not meet the requirement</td>
</tr>
</table>

4.4 VoortVarend Besparen (VVB)

4.4.1 Introduction

Energy efficient navigation can be seen as a broad approach based on knowledge of interactions between ship and engine characteristics (e.g. ship size and hydrodynamics), waterway parameters (e.g. changing waterway depths and the current), ship speed and the resulting fuel consumption. The main objective is reducing the fuel consumption by promoting energy efficient navigation behaviour. This can be done by taking several measures, a popular measure within the category of energy efficient navigation is the program VoortVarend Besparen (VVB). The program has some similarities with the program 'Het Nieuwe Rijden'[13], which is meant for road transport. In the initial stages the program VVB consisted of components like education and training for skippers, the promotion of technical tools like consumption gages and the 'tempomaat' (autopilot system), and the organisation of a C02 competition in which participants tried to sail as efficient as possible, in order to save fuel and reduce emissions (Gille & de Vries, 2011). Recent additions to the programme are an e-learning cursus and the 'Econaut'[14].

The program VVB can be defined as an organizational eco-innovation, while core measures within the program (e.g. training and education) are merely human-oriented approaches which try to stimulate energy efficient navigation behaviour of skippers. A participant describes the program as follows: "The program creates awareness and provides insight on how to sail in an energy efficient way. Actually there were no real eye-openers, but because of the hustle in practice one falls back into the old inefficient patterns." So far a couple of hundred inland shipping companies participated in the program and received a certificate for it (EICB, 2013).

Emission reductions are possible when the participant sticks to the training and education. According to Gille & de Vries (2011) a fuel reduction of 6.7% on average is realized between 2007 and 2010 among participants of the VVB program. It can be assumed that the realized fuel saving resulted in a proportional CO2 and pollutant emission reduction[15]. However, the effectiveness of the VVB program may vary among the different participants. Some skippers already have a very efficient sailing

13 The programme "Het Nieuwe Rijden" has the objective to adjust the driving behaviour of motorists in order to reduce fuel consumption and emissions. Several used measures were offering courses and providing tips (Het Nieuwe Rijden, 2015).
14 This app enables inland shipping companies to calculate their own carbon footprint during a trip, in turn creating awareness about their CO2 performance as compared to the competitor (Groenervaren, 2015).
15 Measures which lead to a reduction in energy (fuel) consumption show a proportional CO2 reduction. NOx emissions are generally more or less linear proportional with CO2 emissions in kg, while PM will probably be reduced somewhat less than proportional. As a first guess, it may be assumed that the total PM and NOx emissions in kg are reduced by the same percentage as the total CO2 emissions and fuel consumption in kg (Maierbrugger, et al., 2015).

behaviour and therefore may not realize the same amount of fuel reduction. Other skippers may have installed additional tools like consumption gages and the 'tempomaat', which contribute to an even larger fuel reduction. Though, according to Gille & de Vries (2011) the amount of 6.7% is a generalizable value.

A total of 3 interviews were held with inland shipping companies that participated in the program VVB and received training and education. Two of the companies are active in the 'wet bulk' segment, one of them manages a fleet of 9 ships and serves shipping companies by collecting ship and cargo-related (liquid) waste. The other company manages two ships and is active in a niche market; the shipping of vegetable fats and oil for the food industry. The remaining third company with one ship is active in the 'dry bulk' and container segments, and has a broad customer base.

The companies are well up to date of the eco-innovations in the sector. The first company active in the 'wet bulk' segment is only involved in the VVB program, whereas the other company in the 'wet bulk' has also a SCR installation in their first ship and a hydrogen injection installation in their second ship. The last mentioned company also considered a hybrid propulsion and LNG as alternative 'green' technology, however it appeared that their ship and operational profile were not suited for these two eco-innovations. Consequently, the barriers for both eco-innovations and in particular for LNG were too high. The third company in this case has in addition to VVB also a SCR&DPF installation in their ship.

4.4.2 Determinants

In the following sections it will be discussed which determinants influenced the decision to participate in the VVB program. As stated in the theoretical framework, these determinants are grouped into external factors, internal factors and the characteristics of the eco-innovation. These determinants will be discussed in the coming sections.

4.4.2.1 External factors

It appeared from the interviews that the Green Award was actually the sole and strongest external driver. The Green Award programme was initially set up in 1994 for maritime shipping and since 2011 there is also a Green Award programme for inland shipping. While the programme receives financial support from the government, it can be considered as part of the external factor 'public policy.' Green Award certifies ships that are extra safe and clean (in terms of emissions). Based on these criteria a ship can receive points and depending on the points a bronze, silver or gold award can be received. By participating in VVB an inland shipping company receives extra points for their Green Award, in case they have one. Depending on the type of award discounts can be received on port dues. For two of the companies this was *the* strongest driver, despite the fact that these discounts are very minimal in absolute terms. In addition to the minor financial benefits, a green award also improves the image and may provide a better position for inland shipping companies when obtaining cargo from customers. One of the interviewees also emphasized this as a minor driver, which indicates that the determinant 'customers' also played a role as driver.

4.4.2.2 Internal factors

There were actually nearly no notable internal factors which played a role either as driver or barrier. One driver however is the 'characteristics of the sector.' One of the interviewees stated that the heavy competition in the sector is "bad for business." As result, the company searched for ways to reduce (fuel) costs and it appeared that the VVB program was a simple and cheap way to realize this. In addition, by participating in the program one acquires points for the Green Award, which is also a way to realize some minimal degree of differentiation.

4.4.2.3 Characteristics of VVB

All three interviewees state that the VVB program consisted of a very simple training and education session. The cost to participate in the program is also very minimal and neglectable, consequently the interviewees did not experience any barriers related to the characteristics of VVB. The most important driver for one of the companies was the potential for cost savings. While during the training and education sessions skippers are made aware on ways to sail in an energy efficient way, by which an inland shipping company might save on fuel costs.

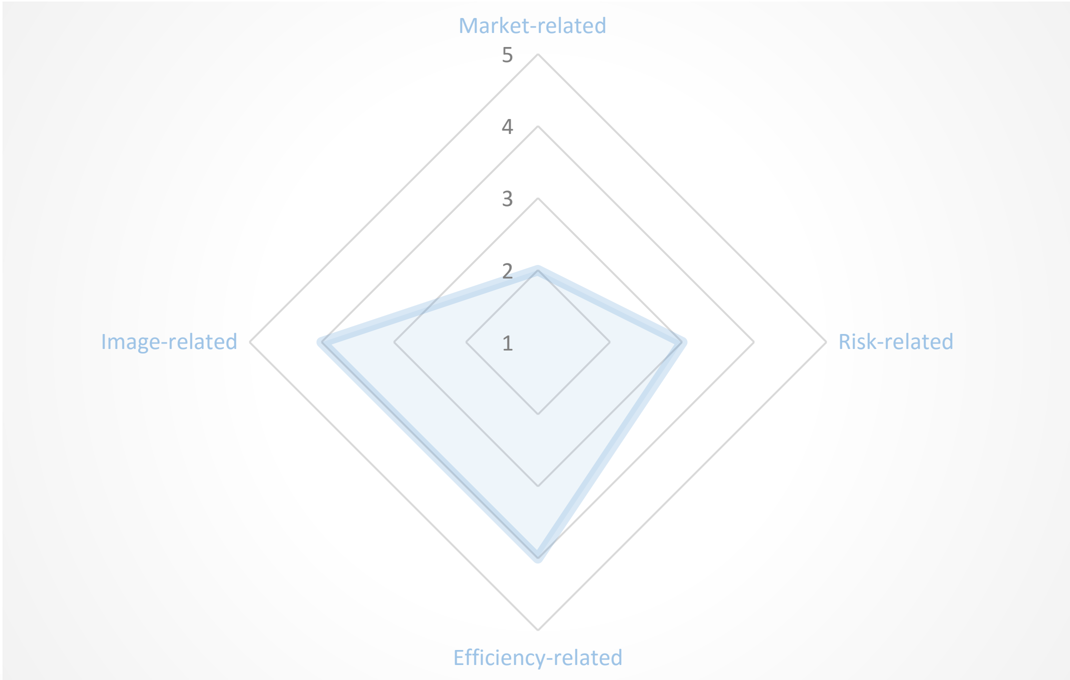
4.4.3 Effects VVB on the competitiveness

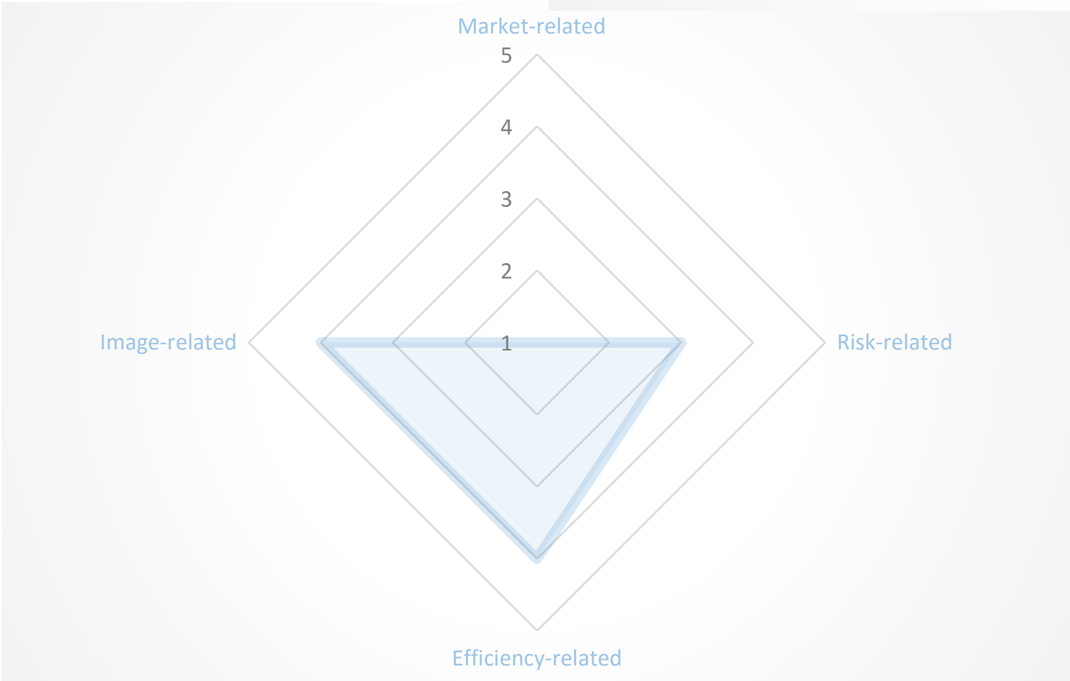
The effects on the competitiveness will be discussed according to the four competitiveness dimensions, as discussed in the theoretical framework. This concerns the market-related, image-related, efficiency-related, and risk-related competitiveness. Figure 13 on the next page summarizes and illustrates the effects on the competitiveness, which are based on the experiences of the three companies in this case.

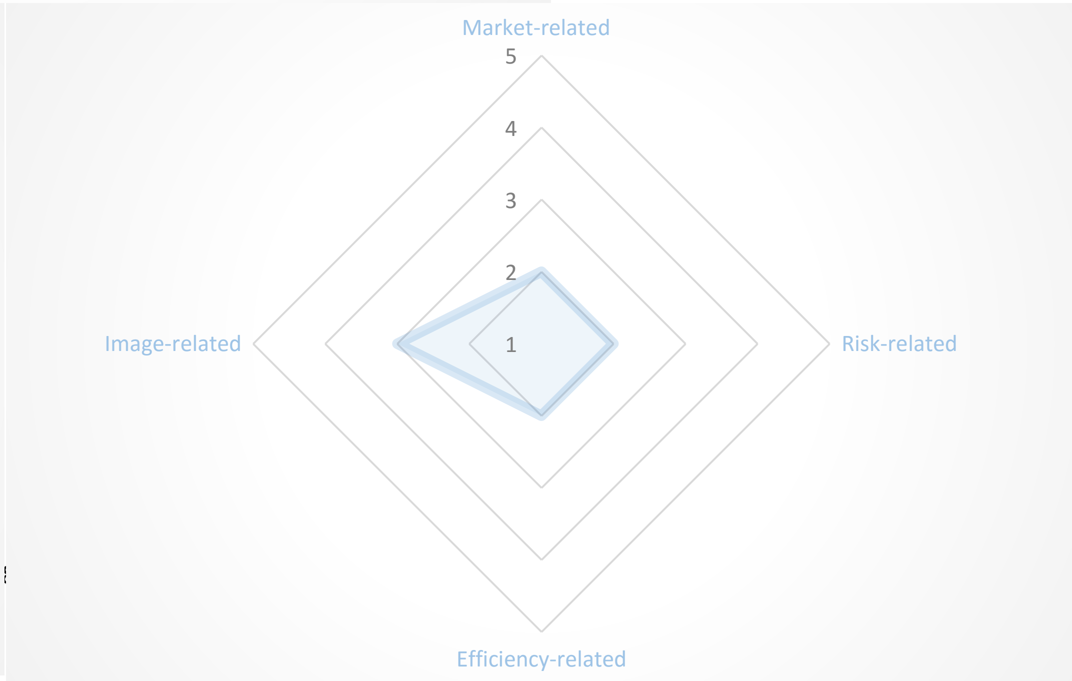
Figure 13

Competitiveness dimensions – VVB

1: Strongly disagree
2: Disagree
3: Neutral
4: Agree
5: Strongly agree







4.4.3.1 Market-related competitiveness

All three interviewees stated that the VVB program did not contribute to the market-related competitiveness. By participating in the program the company indeed receives extra points for the Green Award which has a positive effect on the image of the company. However, this effect is minimal and appeared not enough to recruit more customers or provide new market opportunities.

4.4.3.2 Image-related competitiveness

Two interviewees agree on the positive effect upon the image-related competitiveness. They state for example, that by time to time relevant stakeholders (e.g. customers) visit their ships, and when that happens it gives a positive signal if you can show the VVB certificate. The VVB shows namely that the company is involved in a sustainable initiative. However, an important remark is that this positive signal is quite minimal. A third company takes a more neutral stand and states that he experienced no effect till now, on the other hand he does not deny that VVB might have a (limited) effect on the image.

4.4.3.3 Efficiency-related competitiveness

Two interviewees state that VVB indeed has a positive effect on the efficiency-related competitiveness. Savings on fuel costs can be realized when the tips and tricks learned during the training and education session are also really applied in practice. However, both interviewees also state that it is difficult to identify the exact savings on fuel consumption. A third interviewee does not agree with the statement. The company already does anything to sail in an energy efficient way and the VVB program did not contributed to this in an extra way, while according to the interviewee VVB did not provide any real ‘eye-openers.’

4.4.3.4 Risk-related competitiveness

Two interviewees take a neutral stand, these are also the two that agreed with a positive effect on the efficiency-related competitiveness. While measuring the exact savings on fuel is not possible, it is also not possible to measure any potential amount of emission reduction, which makes it in turn difficult to state whether or not there is an effect concerning environmental compliance. The third company does not agree with the statement. He argues that there is no effect on the efficiency-related competitiveness and consequently there could also be no effect on the risk-related competitiveness. While zero reduction in fuel consumption cannot result in any emission reduction.

4.4.4 Sustained competitiveness

The VVB program will most certainly not contribute to sustained competitiveness for the participating inland shipping company, while it does not meet the requirements of non-substitutability and inimitability. Other energy-efficient navigation related programs like COVADEM are also available, although most are still in the development stage. On the other hand, VVB is certainly not inimitable, while every inland shipping company can participate in the program. Moreover, so far already a couple of hundred inland shipping companies participated in the program and received a certificate for it.

4.4.5 Conclusion

Table 14 shortly summarizes the results of the case on VVB. It appeared that for two of the companies an external factor was the most important determinant, whereas for the remaining third company a factor related to the characteristics of VVB played the most important role. Beyond these two factors and the competition in the sector as third factor, there were no other notable determinants that worked as driver or barrier.

It appeared that VVB's effect on the competitiveness is really limited. No effect has been realized on the market-related competitiveness. VVB has in general a positive, although minor, effect on the image-related competitiveness. Only two companies agree with a positive effect on the efficiency-related competitiveness, however it seems difficult to quantify this effect in terms of fuel consumption reduction. Consequently, the effect on the risk-related competitiveness is uncertain.

A recurring appearance is the relationship between the image- and market-related competitiveness dimensions. It also appeared from previous eco-innovations that in some cases the image-related competitiveness dimension can have a positive effect on the market-related competitiveness dimension, but not necessarily the other way around.

In this case it became also perfectly clear that the efficiency-related competitiveness dimensions can have a positive effect on the risk-related competitiveness dimension, but also not necessarily the other way around. This relationship does not apply for end-of-pipe technologies like a SCR&DPF

installation, while this eco-innovation brings no efficiency related advantages but it does help to comply with environmental legislation.

Table 14: Results VVB

DETERMINANTS		
EXTERNAL *Very important role* Relevant determinants: *- Public policy* *- Customers*	**INTERNAL** *Modest role* Relevant determinants: *- Characteristics of the sector*	**CHARACTERISTICS** *Modest role* Relevant determinants: *- Cost-savings*

COMPETITIVENESS DIMENSIONS			
MARKET 2*Disagree + 1*Strongly Disagree	**IMAGE** 2*Agree + 1*Neutral	**EFFICIENCY** 2*Agree + 1*Disagree	**RISK** 2*Neutral + 1*Disagree

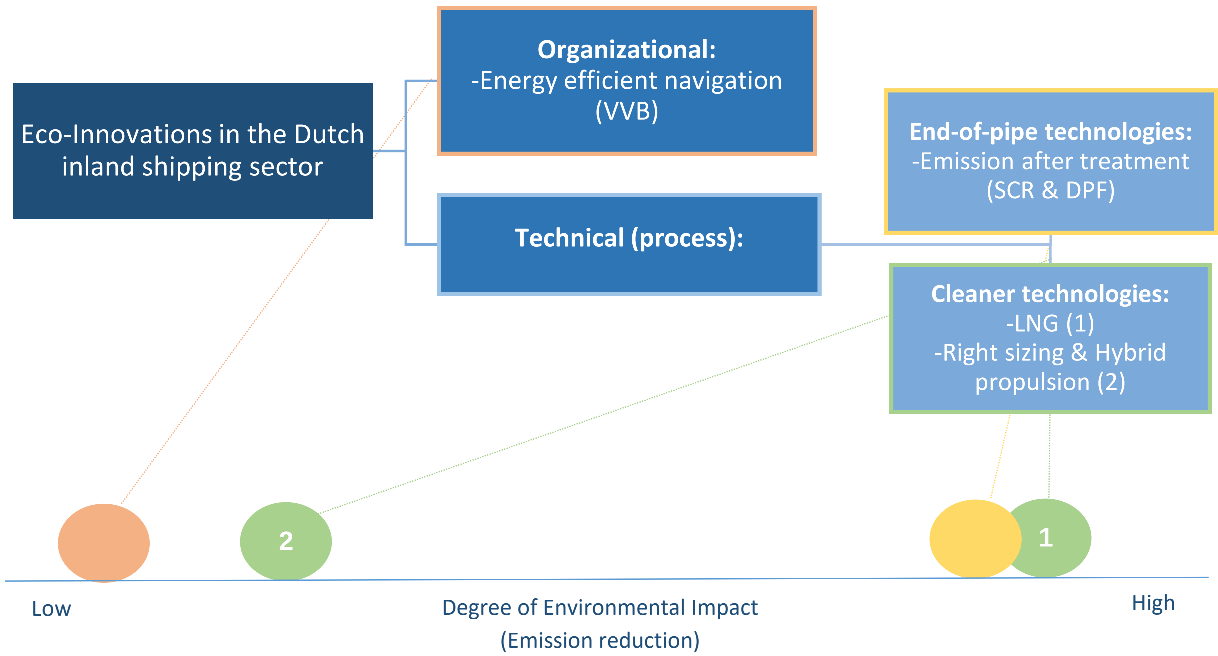
SUSTAINED COMPETITIVENESS	
NON-SUBSTITUTABILITY Does not meet the requirement	**INIMITABILITY** Does not meet the requirement

4.5 Conclusion

First of all, chapter 4 provided some background information which helped to categorize the eco-innovations. In addition, chapter 4 also provides an answer to the fourth sub-question 'What is the current state of eco-innovations in the inland shipping sector?' Currently there are various eco-innovations in the inland shipping sector (e.g. new fuels and propulsion systems). Among these eco-innovations PROMINENT branded five of them as advanced promising concepts for the greening of the inland shipping sector. The current state of these eco-innovations is as follows. So far a couple of hundred inland shipping companies participated in the program VVB. Approximately 70 ships are equipped with either a SCR or DPF, or both. Approximately 17 ships are equipped with a hybrid propulsion or a 'right-sized' engine and 5 ships are equipped with an LNG installation.

These eco-innovations can be categorized based on their characteristics and environmental impact. Figure 14[16] visualizes this categorization:

Figure 14: Typology based on characteristics & environmental impact



It can be seen from the figure that the organizational eco-innovation VVB has relatively the lowest environmental impact in terms of emissions reduction. A relatively higher emission reduction is realisable with a hybrid installation or right-sized engine. It appeared that SCR's and DPF's, which are

[16] Please note that the position of these bulbs on the horizontal axis only provide a rough estimate of the environmental performance. The environmental performance of each eco-innovation is in turn based on the realisable emission reduction.

end-of-pipe technologies, have a larger positive impact upon the environment as compared to hybrid propulsion and right-sizing. However, SCR's and DPF's do not contribute to any reduction in fuel consumption and consequently there occurs nu CO2 reduction. The emission reduction concerns only pollutant emissions. The combination of SCR and DPF may slightly be more effective in reducing pollutant emissions as compared to an LNG installation. However, the realisable CO2 reduction with LNG may more than compensate for this slightly advantage of a SCR&DPF concerning pollutant emissions. Therefore, it can be concluded that among the 5 eco-innovations LNG has the largest positive impact on the environment.

The body part of each sub-chapter discussed the determinants, effects on the competitiveness, and sustained competitiveness. These parts provide an answer to the fifth sub-question: "What are the experiences of eco-innovative inland shipping companies concerning their competitiveness?" All the results are shortly summarized in table 15.

It appeared that the determinants vary per eco-innovation and per company. External determinants played in general an important role as driver for all eco-innovations and in particular for the eco-innovations SCR&DPF, Hybrid propulsion and VVB. In some cases it was mainly public policy that played an important role, whereas in other cases the customer played the most important role as external determinant. Internal determinants played especially an important role for LNG while this eco-innovation requires a lot from the investing company in terms of e.g. absorption capacity and finances. This determinant category played a relatively modest role for the remaining eco-innovations. The characteristics of the eco-innovation played especially an important role for LNG, mainly caused by business development initiatives by two of the companies. The characteristics played a relatively less important role for a SCR&DPF installation and a hybrid propulsion, and for VVB it played even a modest role.

Also the effects on the competiveness varies per eco-innovation, per competitiveness dimension and per company. It seems that LNG and hybrid propulsion have relatively the largest effect on the overall competitiveness as compared to SCR&DPF and VVB. VVB seems to have the smallest impact on the competitiveness. This also shows that eco-innovations with the largest environmental impact (emission reduction) do not necessarily have the largest impact on the competitiveness. The type of eco-innovation however seems to be of relevance for the degree of impact on the competitiveness. Given that LNG and hybrid propulsion have relatively the greatest effect on the competitiveness, it can be stated that cleaner technologies have a relatively greater effect on the overall competitiveness of inland shipping companies as compared to organizational eco-innovations and end-of-pipe technologies.

It appeared that among the four competitiveness dimensions the image- and risk-related dimensions experienced the strongest positive effect. The effect on the efficiency-related competitiveness dimension strongly depends on the type of eco-innovation, LNG & Hybrid propulsion (cleaner technologies) have for example a relatively greater effect on this dimension, whereas SCR&DPF (end-of-pipe technologies) have a slightly negative effect on it. The effect on the market-related competitiveness is limited, only in some cases a positive effect was realized. The strongest drive for shippers/customers is currently the price and not sustainability. However, it is expected that this situation will change in the near future and shippers will attach greater value to 'greener' ships. Two important reasons for this expectation are the expected economic recovery and the increasing environmental awareness in society.

It is evident that all four dimensions are interrelated, while all being part of the comprehensive competitiveness of a company. But apparently there is a relatively strong relation between image- and market-related competitiveness dimensions on the one hand, and efficiency- and risk-related competitiveness on the other hand.

The results show that no eco-innovation will contribute to sustained competitiveness. Only in the case of LNG it may be possible to sustain the competitiveness until the significant barriers become lower and other inland shipping companies may adapt an LNG installation in a relatively easy manner. However, in general the competitive advantages resulting from the stated eco-innovations will most likely only be temporary.

Table 15: Summary results

		LNG	SCR&DPF	HYBRID	VVB
DETERMINANTS	EXTERNAL	Important role *- Public policy* *- Customers* *- Competition* *- Availability of info* *- Research centres* *- Industrial associations*	Very important role *- Public policy* *- Economic climate* *- Customers* *- Competition* *- Availability of info*	Very important role *- Public policy* *- Suppliers* *- Customers* *- Economic climate*	Very important role *- Public policy* *- Customers*
	INTERNAL	Important role *- Financial situation* *- Company size* *- Technological competency (absorption capacity)* *- Environmental strategy & organizational factors*	Modest role *- Characteristics of the sector* *- Environmental strategy & organizational factors*	Modest role *- Environmental strategy & organizational factors*	Modest role *- Characteristics of the sector*
	CHARACTERISTICS	Very important role *- Business development* *- Costs and cost-savings* *- Complexity & compatibility with existing systems* *- Existence of an installed base*	Important role *- Costs* *- Compatibility with existing systems* *- Complementary innovations* *- Existence of an installed base*	Important role *- Costs and cost-savings* *- Complementary innovations* *- Existence of an installed base* *- Compatibility with existing systems*	Modest role *- Cost-savings*
COMPETITIVENESS DIMENSIONS	MARKET	2*Neutral + 1*Agree	1*Neutral + 2* Disagree	1*Neutral + 1*Agree	2*Disagree + 1*Strongly Disagree
	IMAGE	2*Strongly Agree + 1*Agree	1*Strongly Agree + 1*Agree + 1*Disagree	2*Strongly Agree	2*Agree + 1*Neutral

	EFFICIENCY	2*Neutral + 1*Agree	3* Strongly Disagree	1*Neutral + 1*Agree	2*Agree + 1*Disagree
	RISK	2*Agree + 1*Strongly Agree	2*Strongly Agree + 1*Neutral	2*Strongly Agree	2*Neutral + 1*Disagree
SUSTAINED COMPETITIVENESS	NON-SUBSTITUTABILITY	Does not meet the requirement	Does not meet the requirement	Does not meet the requirement	Does not meet the requirement
	INIMITABILITY	Meets the requirement only in the short run	Does not meet the requirement	Does not meet the requirement	Does not meet the requirement

5. Conclusion

5.1 Conclusions

This thesis addressed eco-innovations in the inland shipping sector. Different from standard innovations, eco-innovations primarily aim to benefit the environment. It is the environmental impact that principally describes eco-innovation. These innovations may in turn provide outcomes which are beneficial for both the society and the innovating firm. The potential benefits for an eco-innovative inland shipping company may come in various forms. This matter is at the core of this thesis and consequently the central question is:

"To what extent affects eco-innovation in the Dutch inland shipping sector the competitiveness of inland shipping companies?"

The answer to this question has been obtained through following the theoretical and empirical parts of the thesis. It appeared from the analysis that all stated eco-innovations in this thesis have in general a positive effect on the competitiveness of an inland shipping company. The effect varies however per eco-innovation, per competitiveness dimension and per company. The results show that LNG and hybrid propulsion have relatively the largest effect on the overall competitiveness as compared to SCR&DPF and VVB. VVB seems to have the smallest impact on the competitiveness. Among the four competitiveness dimensions the image- and risk-related dimensions experienced the strongest positive effect. The effect on the efficiency-related competitiveness dimension strongly depends on the type of eco-innovation, LNG & Hybrid propulsion (cleaner technologies) have for example a relatively greater effect on this dimension, whereas SCR&DPF (end-of-pipe technologies) has a slightly negative effect on it. The effect on the market-related competitiveness is limited, only in some cases a positive effect was realized. However, the results show that no eco-innovation will contribute to sustained competitiveness. Therefore, competitive advantages resulting from the stated eco-innovations will most likely only hold in the short-run.

The results show that concerning the eco-innovations in this thesis, there is no trade-off between improving the environmental performance and improving the competitiveness. Consequently, the traditionalist view does not hold in this case. On the contrary, it is the revisionist view that holds, while it appeared that there is a positive relationship between environmental performance and competitiveness. Furthermore, within the revisionist view the 'Porter hypothesis' is very relevant for the eco-innovations in this research. While it appeared from the interviews that among all other determinants, public policy both in the form of subsidies and emission norms, played a very important role as driver of eco-innovations. This justifies the Porter hypothesis, which states that environmental policies may force companies to eco-innovate, which may in turn simultaneously improve the environmental performance and the competitiveness of the company.

5.2 Limitations & Further Research

This subchapter will discuss the limitations of this research which can in turn be included as recommendations for further research on this topic.

There are some limitations associated with the conducted interviews. First of all, the obtained data through the interviews may be biased. This can to an important extent be related to the problem of social desirability. It is possible that the interviewees have given the most socially acceptable answers to the interview questions, especially because of the 'sensitive' subject. The interviewees might pretend for e.g. to be more environmental aware in their actions than this is really the case. A second and important limitation is the fact that it was only possible to conduct 2 interviews with inland shipping companies that adapted a hybrid propulsion, while it was planned to conduct 3 interviews. A third limitation is the quantity of information that was obtained through the interviews, this quantity differs among the eco-innovations. It was for e.g. possible to obtain more information from the companies involved in LNG as compared to companies that participated in the VVB program. Finally, some companies are involved in multiple eco-innovations and it is difficult to control for the effects of these other eco-innovations on the competitiveness of the company. It becomes therefore difficult to measure only the effect of one eco-innovation on the overall competitiveness, ceteris paribus.

A quantitative study on the topic is desirable in order to provide a precise picture on the determinants and in particular the effects on the competitiveness. Within a quantitative study it is highly recommended to control for the different ship types and their operational profiles (number of trips, power demand, fuel consumption, stream velocities, etc.). While it appeared from later discussions with experts in field, that the determinants and effects on the competitiveness may rely to an important extent on these two variables. It is also recommended to take into account the difference between the spot-market and contract-market. The kind of market the inland shipping company is active in may be relevant for the innovation determinants. Being active in the spot-market may for e.g. work as a driver for the adaptation of an eco-innovation, while companies active in the spot-market are financially relatively more healthy.

5.3 Recommendations for branch organizations

If the inland shipping sector wants to protect her position as a relatively sustainable transport modality it has no other option than to eco-innovate. It is in the interest of branch organizations to stimulate the diffusion of eco-innovations in the inland shipping sector. A high diffusion of eco-innovations will improve the performance of the whole sector in terms of sustainability. This will in turn make the modality more attractive for shippers and more shippers may consider inland shipping for the transportation of their goods, which can positively contribute to the modal share of inland shipping in freight transportation. This will be beneficial for inland shipping companies due to increased load volumes and for the society due to a significant cut in emissions.

It appeared from the analysis that eco-innovations are stimulated/discouraged by various determinants from three different categories (external, internal, characteristics). In many cases the determinants work in an intertwined manner. Therefore, stimulating the diffusion of eco-innovations requires action on many fronts.

First of all, the inland fleet consists of various ship types each with a different operational profile. Given the operational profile of a ship it may appear that some eco-innovations are not suitable both in economic and technical terms. So a first step is to identify the existing operational profiles in the inland shipping sector in order to determine which type of eco-innovation is suitable for an x percentage of the inland fleet. This is an ongoing process in the innovation lab, under the guidance of EICB.

A second step is to identify and approach inland shipping companies with relatively ‘polluting’ ships, in order to inform about and encourage for suitable eco-innovations. Inland shipping companies may not be in the position to search for suitable eco-innovations, due to a lack of factors like expertise and time. Therefore, it is necessary that branch organizations actively approach inland shipping companies for this purpose.

A positive and attractive business case will play a key role in convincing the inland shipping companies to adapt the proposed suitable eco-innovation. In order to come up with an attractive business case an eco-innovation should preferably improve the efficiency of the ship, i.e. lower the operational costs. End-of-pipe technologies do not result in any efficiency gains, so therefore other factors should compensate for this.

In addition the investment costs should not be too high, which is for e.g. the case with an LNG installation. Otherwise, Inland shipping companies will not be able to overcome the investment barrier on their own. A possible way to breach the investment barrier for eco-innovations with relatively high investment costs, but also for other eco-innovations, is pooling.

Pooling eco-innovations may help to lower the investment costs due to economies of scale. Suppliers may be able and willing to lower the price in case of relatively large orders. Next to that, pooling eco-innovations may also help to overcome the gap between the 'little innovator' and large European funds, due to the created necessary scale. This will already improve the business case and will in turn positively affect the attitude of banks in providing a potential loan for a partly funding of the project. Pooling eco-innovations into batches with branch organizations leading the project will also relief inland shipping companies and enable them to focus on their core business, which will in turn have a positive effect on their willingness to eco-innovate. Pooling will therefore result in multiple advantages and will prove to be a significant stimulus for the diffusion of eco-innovations.

Next to inland shipping companies, also shippers should be encouraged to stimulate eco-innovations in the sector. For e.g. by agreeing on long term contracts with and choosing more frequently for 'green' inland shipping companies. Public policy should play a role in this, while if the government wants to stimulate inland shipping companies to invest in 'greener technologies', public policy should not only focus on inland shipping companies but also on their customers, the shippers.

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Interview participants

Name	Organistion
Ben Maelissa *(director & co-owner)*	Danser Group
Etienne Wesselman *(commercial director)*	Chemgas Shipping
Ed de Jong *(business developer)*	Deen Shipping
Sebastiaan van der Meer *(co-owner)*	Sendo Shipping
Danny Pols *(owner)*	Scheepvaartbedrijf Vranken
Harm Lenten *(owner)*	H.Lenten Scheepvaart
Jacob Verdonk *(owner)*	Scheepvaartonderneming Anda
Ben Koenen *(owner)*	Intermezzo
Barry de Geus *(operations manager)*	International Slop Disposal / Nature Group
Jan Besemer *(owner)*	Scheepvaartbedrijf Colonia

Discussion participants

Name	Organistion
Khalid Tachi *(director)*	EICB
Bas Kelderman *(project manager)*	EICB
Erwin van der Linden *(project manager)*	EICB
Gertjan Gelder *(sales manager)*	Koedood
Marco van Weerdenburg *(fleet management)*	Dari
Cees Anker *(shore captain)*	Cotrans Scheepvaart

Appendix

Questions for inland shipping companies

1. Zou u kort wat kunnen vertellen over de organisatie?
- Hoeveel en wat voor schepen heeft de organisatie in beheer?
- In welke subsector is de organisatie actief?
- Wie zijn uw voornaamste klanten?

2. Hoe schat u de innovatiekracht van de binnenvaartsector in? Denkt u dat de innovatiekracht verschilt per subsector? Waarom denkt u dat?

3. In hoeverre bent u bekend met de huidige eco-innovaties in de binnenvaartsector?

4. I) Bij welke eco-innovatie(s) bent u betrokken?
II) Waarom?
III) Heeft u andere overwogen?

5. Het besluit om te gaan investeren in een eco-innovatie wordt meestal beinvloed door een wisselwerking van verschillende factoren. Welke factoren zijn van invloed geweest op het besluit om te gaan innoveren? In hoeverre hebben deze factoren het innovatieprocess gestimuleerd/belemmerd? Kunt u dit nader toelichten aan de hand van voorbeelden?

6. Eco-innovaties kunnen een effect hebben op het concurentievermogen van de organisatie. Om het overzichtelijk te houden is het concurrrentievermogen opgedeeld in 4 dimensies:

- Markt-gerelateerde concurrentievermogen
- Imago-gerelateerde concurrentievermogen
- Efficientie-gerelateerde concurrentievermogen
- Risico-gerelateerde concurrentievermogen

I) De eco-innovatie heeft een positief effect gehad / zal een positief effect hebben, op het markt-gerelateerde concurrentievermogen van de organisatie:

- Sterk mee oneens
- Oneens
- Neutraal
- Eens
- Sterk mee eens

Waarom denkt u dat? Hoe denkt u dat het heeft bijgedragen / zal bijdragen aan het concurrentievermogen (of juist niet)? Kunt u dit nader toelichten aan de hand van voorbeelden?

II) De eco-innovatie heeft een positief effect gehad / zal een positief effect hebben, op het imago-gerelateerde concurrentievermogen van de organisatie:

- Sterk mee oneens
- Oneens
- Neutraal
- Eens
- Sterk mee eens

Waarom denkt u dat? Hoe denkt u dat het heeft bijgedragen / zal bijdragen aan het concurrentievermogen (of juist niet)? Kunt u dit nader toelichten aan de hand van voorbeelden?

III) De eco-innovatie heeft een positief effect gehad / zal een positief effect hebben, op het efficientie-gerelateerde concurrentievermogen van de organisatie:

- Sterk mee oneens
- Oneens
- Neutraal
- Eens
- Sterk mee eens

Waarom denkt u dat? Hoe denkt u dat het heeft bijgedragen / zal bijdragen aan het concurrentievermogen (of juist niet)? Kunt u dit nader toelichten aan de hand van voorbeelden?

IV) De eco-innovatie heeft een positief effect gehad / zal een positief effect hebben, op het risico-gerelateerde concurrentievermogen van de organisatie:

- Sterk mee oneens
- Oneens
- Neutraal
- Eens
- Sterk mee eens

Waarom denkt u dat? Hoe denkt u dat het heeft bijgedragen / zal bijdragen aan het concurrentievermogen (of juist niet)? Kunt u dit nader toelichten aan de hand van voorbeelden?

7. In hoeverre denkt u dat de gekozen eco-innovatie niet-substitueerbaar is voor de organisatie en niet-imiteerbaar is voor de concurrent?