



Nr C 365
July 2019

Environmentally differentiated port dues

Final report

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In cooperation with: Gothenburg University (GU), Swedish National Road and Transport Research Institute (VTI), Port of Gothenburg, Ports of Stockholm, Port of Trelleborg

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Funded by: Vinnova

Photo: Pixabay

Report number: C 365

ISBN: 978-91-7883-125-8

Edition Only available as PDF for individual printing

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This report has been reviewed and approved in accordance with IVL's audited and approved management system.

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Executive summary

Objective

This is the final report of the research project *Environmentally differentiated port dues*. The purposes of the research are to examine how environmentally differentiated dues and incentives in ports can reduce the environmental impact caused by transport modes that call at the port, and their consequences from legal, policy and goods flow perspectives. Both land and sea transport are addressed. The project examines how ports, as important parts of international transport chains, can contribute to the environmental and climate objectives, by introducing environmentally differentiated port dues to promote a shift to more environmentally efficient transport, vehicles, ships, technologies and alternative fuels.

Organisation

The project was funded by Vinnova - Sweden's Innovation Agency. The project group consisted of researchers with competencies represented in many fields including business administration, law, policies, economics, logistics and environmental science, as well as representatives from three Swedish ports with extensive experiences in environmental management in port operations. The following organisations were represented in the project group: IVL Swedish Environmental Research Institute (project manager), Gothenburg University (Department of Business Administration, Law Department and Department of Economics), VTI Swedish Road and Transport Research Institute, Port of Gothenburg, Ports of Stockholm and Port of Trelleborg. The work was presented and discussed at four meetings with the reference group, and during individual interviews with the representatives. This contributed to an exchange of ideas and knowledge between the involved parties and facilitated a dissemination of results. The reference group consisted of representatives from the transport industry, cargo owners and authorities: Schenker Air & Ocean, the Swedish Transport Administration, Swedish shipowners' Association, Ports of Sweden, Stena Line, Region Västra Götaland, the Swedish Transport Agency, Clean Shipping Index, the Swedish Maritime Administration, Stora Enso Logistics and Port of Karlskrona.

Outline and summary of results

The project started with a mapping of environmentally differentiated port dues and incentives. Relevant international measures, fees and indexes were identified, followed by a selection of five dues and incentives for land transport and five for shipping that were discussed and examined in a combined project group and reference group meeting. The result showed that there are many initiatives in ports around the world both directed towards sea and inland transport. Approximately 20 Swedish ports have today environmentally differentiated dues for ships, but no incentives were found for inland transport. The results are found in *Chapter 2 Mapping of environmentally differentiated dues and incentives*.

In the next step, two incentives for land transport and two for sea transport were selected for a deeper analysis:

1. Environmental differentiation of port dues related to measures to **reduce NO_x emissions from ships**, rebate of 0.50 SEK/gross ton is suggested for vessels whose auxiliary engines emit less than 3g NO_x per kWh,
2. 15% discount on the port due **for ships that slow down in the fairway channel** with a maximum speed of 12 knots in a zone of 20 nautical miles (NM) from the port,
3. **Congestion gate fees of 200 SEK per truck** including all trucks at the terminal gate that call at the port during peak hours, and
4. **Environmental gate fee of 200 SEK per truck** including trucks at the terminal gate, with a 50% discount for Euro class 6 and a 100% discount for electric/hybrid vehicles and gas vehicles.

These four incentives were included in the environmental analysis in *Chapter 3 Environmental and energy analysis of road and sea transport*. The three ports included in the project group, Port of Gothenburg, Ports of Stockholm and Port of Trelleborg, were used as case ports for the environmental analysis of these incentives. The result showed that ports with the investigated rebates for the seaside (i.e. incentives 1 and 2), potentially could reduce the CO₂ and NO_x emissions with up to 3% with a rather modest compliance level. Port gate observations on the landside were carried out in Stockholm and Gothenburg container terminals to collect data on size of the trucks, Euro class and number of containers loaded. Own observations were necessary because the information of how road transports were carried out to/from ports was inadequate. This investigation has shown that the road-based container transports to and from the ports seem to operate under non-optimal conditions. Many trucks arrived to or left the terminal with no load, the majority of the trucks had a capacity of 2 TEUs (twenty-foot equivalent units for container capacity) even though larger trucks were allowed, and 10-25% of the trucks were using outdated high polluting engines (Euro class 2 or 3). This means the truck traffic, through the densely populated areas of the port cities cause unnecessary disturbances in the form of congestion, noise and air pollution.

The consequences of a gate fee of 200 SEK per truck (base case) as well as higher and lower levels were examined from a goods flow perspective (Chapter 4). Further, the land-based incentives (i.e. incentives 3 and 4) were analysed from a legal perspective (Chapter 5), and from policy perspectives (Chapter 6 and Chapter 7).

Chapter 4 Impacts of different national infrastructure fees and taxes comprises an ex-post analysis of the Swedish environmentally differentiated fairway dues and an ex-ante analysis of different other national infrastructure fees and taxes. For the later, the Swedish national freight transport model Samgods, was used to simulate the impacts of different national infrastructure fees and taxes on the choice of the transport chains. The model is based on an optimization routine that minimizes the shippers' annual logistics costs. If gate fees for trucks are applied in all Swedish ports, the model predicts an increase in transport on rail and road, and a decrease in sea transports. Gate fees of 200 SEK per truck applied in all Swedish ports are calculated to reduce the total throughput in all ports by approximately 2%. If gate fees were only implemented in the ports of Gothenburg, Stockholm, and Trelleborg, cargo tend, to some extent, to move to competing ports in the same region.

From a legal perspective, some difficulties have been identified related to the gate fees for trucks. One issue is to determine if the suggested fee, legally, is classified as a tax, a fee, a duty or charges. This include assessment of both national and EU legislative sources. The constitutional legal framework must be considered before a possible implementation of the suggested fees. The main criterion for the EU is that the fee or tax cannot have discriminatory effects or hinder the free movement of goods or services. A more detailed design of the truck fee is needed to investigate how

to implement it from a national legislative perspective. Taxes must be decided by the Parliament, while there are some possibilities to delegate powers regarding fees. The independence of the municipality can also give rise to a municipal decision on fees to a certain extent but depend on the ownership structure of the ports. This is further described in *Chapter 5 Systematization and classification of port fees and its compatibility with national, regional and international regulations*, which also includes a description of ownership structures in the main Swedish ports and a systematization of norms critical for port and entry fees on the landside.

Different policy options to implement truck fees in Swedish ports are described in *Chapter 6 Alternative environmental policy measures for city ports' inland transports – an overview*. National measures covering all ports discussed in this report are: 1. Environmental tax on trucks entering a port area; 2. Environmentally differentiated state fee on trucks entering a port area; 3. Law on land-based port fee, and 4. Voluntary fee-system set by port operators. Individual port measures could be: 1. Developed congestion taxes, 2. Environmental fees set by the port operator on request by the port environmental permit, and 3. Environmental fees set by the port operator in an agreement with the state to get infrastructure investments. Reasons for a port to introduce environmental dues could, beside a genuine interest in the environmental issue, be that the port wants to be pro-actively green for reasons of image or to prevent public action and avoid complaints from neighbors and from the local community.

The need for policies due to different market failure is discussed in *Chapter 7 Cost-effective instruments and policy feasibility*. It is argued that the situation differs between different market failures: for congestion, for local externalities, and for regional and global externalities. Traditionally, transport policy making has occurred at the national level simply because of the power to implement and enforce. In shipping, existing policy instruments are few largely due to the international characteristics of the business and difficulties in deciding on global instruments.

Conclusions

Environmentally differentiated port dues in Swedish ports have historically only targeted ships. From a global outlook, the potential to target also trucks with a similar fee structure based on environmental performance seems high. However, some aspects need further studies before conclusions can be drawn on effects and recommendations can be made, including legal aspects of an introduction of fees for land-based transports to and from the port. Further, better knowledge of the road logistic set up and types of trucks used (e.g. Euro class, truck size, the load capacity and the amount of cargo loaded, charging/discharging locations, used routes through the urban area, etc.) are necessary to design a system of environmentally differentiated fees in ports for road transport. Measures to reduce trucks' emissions and congestion in the vicinity of ports have so far received limited attention among Swedish ports.

This research indicates that port authorities in Sweden that have implemented environmentally differentiated port dues for ships have contributed to the implementation of emission abatement measures on ships. Incentives from different actors that support each other strengthen this effect. Harmonization of the environmental differentiation of port dues on a large geographic scale is therefore needed to achieve further emission reductions from ships in ports. In general, policies and regulations are necessary for the transport sector to reach its climate and environmental objectives.

The following conclusions have been drawn from this project:

- To accomplish rapid change, many actors, including ports, need to cooperate and contribute. Environmentally differentiated port dues can be one solution, among others, to promote a shift to more environmentally efficient transport, vehicles, ships, technologies and alternative fuels.
- Port authorities have the potential to put more pressure on road haulers than is done in Sweden today. This could benefit the environment in port cities with intense road traffic to and from the port through the city.
- The widespread use of environmentally differentiated port dues for ships in Sweden indicates that, on the seaside, this is not a controversial issue. For land transport, the situation is somewhat different, and there are currently no environmentally differentiated land-based port dues in Swedish ports.
- From a legal perspective, some difficulties have been identified related to the gate fees for trucks. A more detailed design of a truck fee system is needed to investigate how to implement it from a legislative perspective.
- Before introducing new tariffs on truck transports on a larger scale, the risk of sub-optimization needs to be carefully analysed. The port dues expected to bring beneficial effects on society, such as less congestion, accidents, emissions and noise, need to be comprehensively evaluated before implementation.
- Observations at two container terminals have shown that the road-based container transports to and from the ports seem to operate under non-optimal conditions. Empty, small and old trucks with high-polluting engines were observed.
- The overall results of the ex post analysis of the environmentally differentiated fairway dues in Sweden 1998 – 2017 is that the benefits for society of reducing both SO_x and NO_x emissions to air exceed the costs. However, reducing these emissions has not been economically profitable for many ship owners/operators.
- Based on the principle of cost minimization, gate fees of 200 SEK per truck in all Swedish ports are calculated to reduce the total throughput in all ports by approximately 2%.
- The introduction of the road fee is calculated to have by far the largest individual impact on reducing air emissions among investigated national infrastructure fees and taxes. The impact increases slightly when the road fee is combined with other national fees.
- Reasons for voluntarily introducing environmentally differentiated dues in a port could be: an interest in the environment, a desire to be proactive green or to prevent public action and avoid complaints from neighbors or the local community.
- Introduction of environmentally differentiated port dues globally, or at least in the EU, would include greater incentives for shipping companies and ship owners to invest in, emission abatement technologies or use alternative fuels. A national wide coverage may also eliminate unfair competition between different Swedish ports, however being more difficult to adjust to local environmental conditions.

1. Introduction

Author: Linda Styhre, IVL Swedish Environmental Research Institute

The first chapter introduces the project *Environmentally differentiated port dues*. The project, funded by Vinnova - Sweden's Innovation Agency, was carried out between November 2016 and January 2019 by eight organisations with support from a reference group. Great effort has been made to disseminate the result, and a list of publications and presentations is found in the chapter.

1.1 Background

This is the final report of the MAI¹-project (Environmentally differentiated port dues). The purpose of the research is to examine how environmentally differentiated dues and incentives in ports can reduce the environmental impact caused by transport modes that call at the port from an interdisciplinary approach, including environmental, legal, policy and logistics perspectives. Both land and sea transport are addressed.

The idea behind this project was to examine if ports, as central parts of transport chains, could contribute to our environmental and climate objectives by introducing environmentally differentiated port dues to promote a shift to more environmentally efficient transport, vehicles, ships, technologies and alternative fuels. Further, if these dues or incentives proved to be effective, would it be possible to implement them at national or individual level, from legal and political points of view; and would there be consequences for goods flows and ports' competitiveness?

According to the European Environmental Agency, transport consumes one third of all final energy in the EU and accounts for more than one quarter of the EU's total greenhouse gas emissions. While most other sectors have reduced their emissions the last 30 years, those from transport have risen. Emissions from shipping have impacts on the climate, environment and human health. Overall, emissions from the shipping sector increase, and efficient regulations are lacking. International shipping contributes approximately 2.4% of global greenhouse gas (GHG) emissions, and its share is expected to increase in the future (International Maritime Organization, 2014). Transport is also responsible for a large share of urban air pollution as well as noise.

A port is not the actor with the largest influence on transport generated emissions but can still play an important role in reducing emissions from ships and trucks in the port surroundings. Environmentally differentiated port dues have received increased attention in the last years. This research contributes to an increased knowledge of the effect of available measures in a Swedish context. Many ports focus on the reduction of energy consumption and air emissions from their own activities, mainly caused by work machinery, which is beyond the objective of this project.

It is not an easy task to calculate the effect of environmentally differentiated port dues or incentives, because of difficulties in grasping the causes of an investment in abatement technologies or changed behavior. Consequently, only few port authorities are able to monitor the effects of the scheme they have implemented. Further, a study carried out by Consulenti per la Gestione Aziendale (COGEA) on behalf of the European Commission (COGEA, 2017) concludes that environmentally

¹ Miljöstyrande Avgifter och Incitament för hamnar (MAI)

differentiated port dues alone cannot be a decisive factor to persuade ship owners to adopt these technologies but can under certain conditions reduce the payback period of the investment. This complexity is also discussed by von Bahr et al. (2019). They carried out interviews with people in decision-making positions at ten shipping companies who have invested in environmental abatement equipment or technologies for their vessels. The shipping companies all have traffic to and from Swedish ports and have received significant environmental discounts. The result showed a diversified picture of the importance of the environmental differentiation of port dues for these investments, but environmentally differentiated port dues and fairways dues contributed to at least some of the shipping companies' investment decision in abatement technologies. All the shipping companies stated that environmentally differentiated port dues are good incentives but suggested that the same type of charging should apply in all Swedish port or in the EU, and perhaps even be coordinated within the International Maritime Organization (IMO).

Both introduction of environmentally differentiated port dues in a larger geographical area (at least nationally, but preferably internationally) or in an individual port is discussed in this report. The geographical scope has a large effect on the regulatory perspective. The benefit of coordinating the environmental differentiation of port dues among Swedish ports, with other EU countries or even in a larger global context, is that shipping companies and road hauliers get better incentives for environmental improvement measures. However, voluntary environmentally differentiated port dues can be a good approach for individual ports to pursue their environmental commitment and to take social responsibility and benefit their image.

1.2 Outline and contribution

1.2.1 Organisation

The MAI-project was funded by Vinnova and carried out in a project group that consisted of IVL Swedish Environmental Research Institute (project manager), Gothenburg University (Department of Business Administration, Law Department and Department of Economics), VTI Swedish Road and Transport Research Institute, Port of Gothenburg, Ports of Stockholm and Port of Trelleborg. The research group (IVL, Gothenburg University and VTI) designed and conducted the studies and contributed to this report. These researchers have competencies represented in many fields, including business administration, law, economics, logistics and environmental science, which were combined with the practical experience gathered at the three ports in Gothenburg, Stockholm and Trelleborg. The role of the ports was to provide the project with information, knowledge and port call and vehicle statistics for the environmental calculations. The involvement of the ports was very appreciated and important for the project; it gave a better understanding of the diverse conditions in Swedish ports and contributed to the validation of the results during the project different phases.

The project was carried out by the project group, but the work was continuously discussed and anchored in a reference group with representatives from the transport industry and authorities. The reference group consisted of representatives from the following organisations: Schenker Air & Ocean, the Swedish Transport Administration, Swedish shipowners' Association, Ports of Sweden, Stena Line, Region Västra Götaland, the Swedish Transport Agency, Clean Shipping Index, the Swedish Maritime Administration, Stora Enso Logistics and Port of Karlskrona. Further AMP Terminals participated in the third reference group meeting.

1.2.2 Meetings

The representatives of the reference group participated in four meetings and each member was also interviewed separately for individual feedback on the incentives analysed in the project. Additional meetings and discussions were also held by several of the members of the reference group during the project. The results of these meetings are included in this report.

Four reference group meeting was organized by the project:

- 1st meeting 7 February 2017 – Kick-off and information sharing.
- 2^d meeting 12 June 2017 – Evaluation of ten suggested dues and incentives (five for land and five for sea).
- 3^d meeting 1 February 2018 – Expert elicitation to evaluate four dues/rebates (NO_x-rebate for ships, slow steaming approaching a port, congestion charge for trucks, environmental port dues for trucks). Presentation of preliminary results from WP 3, WP 4 and WP 5.
- 4th meeting 9 October 2018 – presentation and validation of results.

1.2.3 Work packages and project outline

The outcomes of the four work packages in the MAI-project are included in this report (excluded are activities in Work packages 1 “Project management and dissemination”). Each chapter has a responsible author/s, where the individual research and findings are described. The project leader, Linda Styhre at IVL Swedish Environmental Research Institute, was responsible for writing *Executive summary, Chapter 1 Introduction and Chapter 8 Conclusions*.

The outline of the project including the different work packages and the main internal connections are shown in Figure 1.

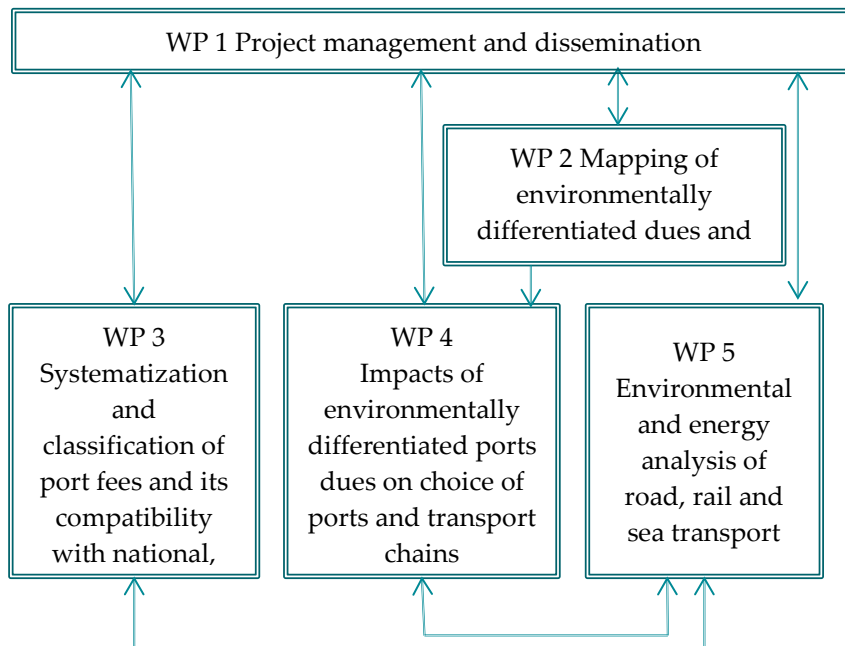


Figure 1 Work packages and connection in the MAI-project.

In WP 2 “Mapping of environmentally differentiated dues and incentives” available dues and incentives for inland transport were mapped and analysed by the Department of Business

Administration at Gothenburg University and for sea transport by IVL Swedish Environmental Research institute. First, all relevant international incentives, fees and indexes were mapped, followed by a selection of five dues/incentives for land and five for sea that were discussed and examined at the second reference group meeting. The results of WP 2 are found in *Chapter 2 Mapping of environmentally differentiated dues and incentives*.

The Department of Law at Gothenburg University worked in WP 3 “Systematization and classification of port fees and its compatibility with national, regional and international regulations”. The purposes of this work were to increase the knowledge regarding the theoretical framework for port- and entry fees as well as already existing port- and entry fees on the landside, both at the national and the EU level. The work also comprises a description of the most relevant regulatory problems connected to two specific truck fees developed and analysed in WP 5. A summary of the outcome of the work is included in *Chapter 5 Systematization and classification of port fees and its compatibility with national, regional and international regulations*.

In WP 4 “Impacts of environmentally differentiated port dues on choice of ports and transport-chains”, VTI Swedish Road and Transport Research Institute worked on two issues: 1. the impact of Sweden’s environmentally differentiated fairway dues, and 2. the impact of different national infrastructure fees and taxes on choice of ports and transport chains. In the second part, simulations were carried out using the Samgods model based on hypothetical port gate fees of SEK 50, 100, 200, 300, 500 and 1000 per truck passage in all Swedish ports, based on analysis in WP 5. Based on WP 5 a gate fee of 200 SEK is assumed as “base case”. The results are found in *Chapter 4 Impacts of different national infrastructure fees and taxes*. WP 4 also includes the work related to policy analysis and description of instruments appropriate for ports performed by the Department of Economics at Gothenburg University. This work is included in *Chapter 8 Cost-effective instruments and policy feasibility*.

The work by IVL Swedish Environmental Research Institute carried out in WP 5 is included in *Chapter 3 Environmental and energy analysis of road and sea transport*. Expected effects on the level of emissions were calculated for two incentives for land transport and two for sea transport, including uncertainty and sensitivity analysis for sea transport. The three ports included in the project group, Port of Gothenburg, Ports of Stockholm and Port of Trelleborg, were used as case ports. Port call statistics were received for the three ports in order to first calculate total emissions from ships in port, and next to investigate expected changes in emissions if rebates were introduced. For land transport, truck movement data were collected by IVL in Ports of Stockholm and Port of Gothenburg. In order to better understand the consequences of the design of a gate fee system for trucks, policy and legal experts at IVL were engaged at the end of the project. Their conclusions are included in *Chapter 6 Alternative environmental policy measures for city ports’ inland transports – an overview*.

Chapter 8 Conclusions summaries the concluding remarks and present future research identified by the researchers. *Appendix* includes material presented or used at the reference group meetings.

1.2.4 Authors

The following authors have been involved in the MAI-project and have contributed to this work:

Linda Styhre, IVL Swedish Environmental Research institute: Executive Summary, Chapter 1 Introduction, and Chapter 8.1 Concluding remarks.



Marta Gonzalez-Aregall and **Rickard Bergqvist**, Gothenburg University, Department of Business Administration: Chapter 2.1 Inland transport in Chapter 2 Mapping of environmentally differentiated dues and incentives.

Sara Sköld, IVL Swedish Environmental Research institute: Chapter 2.2 Sea transport in Chapter 2 Mapping of environmentally differentiated dues and incentives.

Sebastian Bäckström, IVL Swedish Environmental Research institute: Chapter 3.1 Environmental analysis of incentives for inland transport in Environmental and energy analysis of road and sea transport.

Hulda Winnes and **Rasmus Parsmo**, IVL Swedish Environmental Research institute: Chapter 3.2 Environmental analysis of incentives for sea transport in Chapter 3 Environmental and energy analysis of road and sea transport.

Cecilia Hult, IVL Swedish Environmental Research institute: Chapter 3.3 Uncertainty and sensitivity analysis – sea transport in Chapter 3 Environmental and energy analysis of road and sea transport.

Karl Jivén, IVL Swedish Environmental Research institute: Chapter 3.4 Interviews with reference group members in Chapter 3 Environmental and energy analysis of road and sea transport.

Inge Vierth and **Rune Karlsson**, VTI - Swedish Road and Transport Research Institute: Chapter 4 Impacts of different national infrastructure fees and taxes.

Pernilla Rendahl and **Ann-Sophie Sallander**, Gothenburg University, Law department: Chapter 5.1 Introduction and 5.2 Step 3: Comment and recommendations concerning proposed truck fees in Chapter 5 Systematization and classification of port fees and its compatibility with national, regional and international regulations.

Lars-Göran Malmberg, Gothenburg University, Law department: Chapter 5.3 Step 2: Port ownership – conclusions in Chapter 5 in Systematization and classification of port fees and its compatibility with national, regional and international regulations.

Åsa Romson and **Jenny von Bahr**, IVL Swedish Environmental Research institute: Chapter 6 Alternative environmental policy measures for city ports' inland transports – an overview.

Thomas Sterner, Gothenburg University, Department of Economics: Chapter 7 Cost-effective instruments and political feasibility.

1.3 Dissemination of project results

1.3.1 Peer-review articles

Gonzalez-Aregall, M; Bergqvist, R and Monios, J (2018) "A Global Review of the Hinterland Dimension of Green Port Strategies", *Transportation Research Part D: Transport and Environmental*, 59, 23-34. <https://doi.org/10.1016/j.trd.2017.12.013>

Sallander, A-S. (2018) Normgivningsfrågor och gränsdragningsproblematik rörande skatter och avgifter. The article is reviewed and published in *Förvaltningsrättslig tidskrift*, FT 2018/4 p. 747-787.

Rendahl, P. (2019) The Scope for Member States to introduce Taxes, Charges and Fees on Harmful Substances: A Swedish Perspective (preliminary title). The article is currently under review by European Law Review.

Vierth, I., Karlsson, P and Lindé, T. (2019) "How to achieve less emissions from freight transport in Sweden" Maritime Business Review, Vol. 4 (1) p. 4-15.

<https://www.emeraldinsight.com/doi/full/10.1108/MABR-09-2018-0032>

1.3.2 Book chapters

Gonzalez-Aregall, M. and Bergqvist, R (forthcoming) "Green Port Initiatives for a More Sustainable Port-City Interaction: The Case Study of Barcelona", Chapter 9 in the book: "Maritime Transport and Regional Sustainability", Edited by: Adolf Ng, Jason Monios, and Changmin Jiang. Elsevier Edition.

Monios, J. and Bergqvist, R., (2018) "Green ports in theory and practice", in "Green Ports: Inland and Seaside Sustainable Transportation Strategies", Edited by: Rickard Bergqvist and Jason Monios, Elsevier Edition.

Gonzalez-Aregall, M; Bergqvist, R and Monios, J (2018) "Port-driven measures for incentivising sustainable hinterland transport", Chapter 10 in the book: "Green Ports - Inland and Seaside Sustainable Transportation Strategies", Edited by: Rickard Bergqvist and Jason Monios. Elsevier Edition.

Sköld, S. (2018) "Green port dues – Indices and Incentives Schemes for Shipping", Chapter 9 in the book: "Green Ports - Inland and Seaside Sustainable Transportation Strategies", Edited by: Rickard Bergqvist and Jason Monios. Elsevier Edition.

Fridell, E. (2018) "Emissions and Fuel Use in the Shipping Sector", Chapter 2 in the book: "Green Ports - Inland and Seaside Sustainable Transportation Strategies", Edited by: Rickard Bergqvist and Jason Monios. Elsevier Edition.

Styhre, L. and Winnes, H. (2018) "Emissions from ships in ports", Chapter 6 in the book: "Green Ports - Inland and Seaside Sustainable Transportation Strategies", Edited by: Rickard Bergqvist and Jason Monios. Elsevier Edition.

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2. Mapping of environmentally differentiated dues and incentives

The second work package, Mapping of environmentally differentiated dues and incentives, is focused on developing two benchmarking studies for both sea and land perspectives. Initiatives have been studied more in detail in the subsequent work packages. Chapter 2.1 include Inland transport and Chapter 2.2 Sea transport.

2.1 Inland transport

Authors: Marta Gonzalez-Aregall and Rickard Bergqvist, Gothenburg University, Department of Business Administration

2.1.1 Context

This chapter reports the results related to incentives and fees established by ports in order to improve the environmental performance of their connecting transport network, that is, from a landside perspective. Thus, this study has the following objectives: first, identifying and analysing real case studies related to port-initiated incentives for more sustainable transport; secondly, to be a guide for port agents in implementing environmental performance instruments; and finally, to evaluate the feasibility of different port-initiated incentives from the perspective of Swedish stakeholders.

2.1.2 Methodology and result

The recent increase in freight traffic has challenged the movement of goods and the traffic distribution through intermodal transport chains. In the context of vital interface between land and sea, port hinterland connections have become essential for firms and port competition. Therefore, part of the environmental effect of shipping happens in the port zone or in the nearby area (OECD, 2011). As a result, in the last decades, ports have recognized the environmental externalities of logistics and transportation and have started to develop green policies (Bergqvist and Egels-Zandén, 2012) and promote the composition of sustainable transport solutions through environmental strategies.

Besides the port and maritime community, several governments and institutions have initiated studies, strategies and actions to improve the environmental performance.

From a general perspective, several public institutions have implemented different environmental performance strategies. Firstly, international institution like the World Port Climate Initiative (WPCI) provides new steps towards becoming greener. Secondly, many regional institutions in Europe (the European Sea Ports Organization, the NoMePorts project or the Baltic Port Organization) and America (the American Association of Port Authorities) provide new systems to promote environmental initiatives.

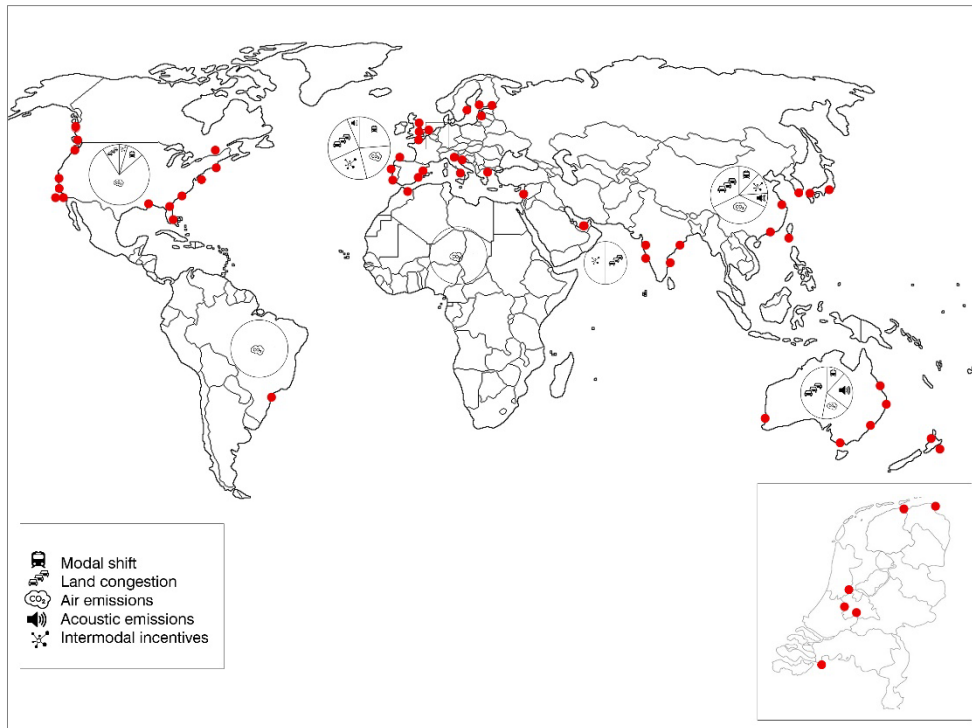
From a specific perspective, government strategies like EcoBonus System in Sweden, private policies and port authority have developed plans for more environmentally friendly inland transport. In

particular, this research has a focus on port authorities' initiatives and specific private firms' strategies that are present in ports hinterland logistics.

In contrast to analysing the "green" incentives and port dues related to the seaside, this chapter has a focus on hinterland logistics. Furthermore, through an analysis of several case studies around the world, it has been identified and analysed five main incentives from a Swedish perspective with the help of key stakeholders. Thus, this study permits proposed measures based on effect and feasibility for further research as well as examines how different port agents evaluate specific situations in the Swedish system.

In order to consider as many case studies as possible, a snowball technique was used, based on several sources to compile a comprehensive list of port authorities, resulting in a total of 365 port authorities active in container handling. The study started by matching the IAPH database and the World Port Ranking in order to create a common list of port authorities. The next step was to determine which ports were active in sustainable hinterland strategies. Therefore, a qualitative review was conducted by the authors of all relevant and available documentation on these ports, such as port authority websites, annual reports, project documents like Bestfact case studies, Green Port projects and private firms' internet sites. More information was sought from secondary research such as academic studies and official reports of public institutions (e.g. UNECE, 2010; OECD, 2011; UNCTAD, 2016). A snowball technique was followed, searching all available sources of data until data saturation was reached and no new information was found.

Based on the study of Svensson and Andersson (2011) and in order to analyse and homogenize all different case studies, we have developed a set of criteria based on the objective and the application. On the one hand, there is the objective (goal), i.e. the main objective of the measure. In this regard, five main goals have been considered: air emission, noise, land congestion, intermodal incentive and modal shift. On the other hand, there is the application (design), i.e. how the incentive had been implemented. Thus, ten types of applications have been identified: certification, concession contract, dedicated infrastructure, engine, improve knowledge, monitoring program, port dues and subsidy funds, regulatory instrument, specific mode of transportation and technology. In total, this study identified 76 cases with 165 initiatives worldwide. Figure 2 shows the location of all case studies considered on this research.



Source: Own elaboration

Figure 2 Location of case studies.

Table 1 summaries all cases and incentives according to different regions, revealing that Europe is the region with the most cases, followed by North America and Asia with the same number of cases, although North America has more measures implemented than Asia. Middle East, Africa and South America are the regions with the lowest number of case studies.

Table 1 Summary of all different case studies by location and incentives.

	Case studies	Incentive /tool
Africa	1	1
Australia	9	20
Asia	17	29
Europe	29	67
Middle East	2	2
North America	17	45
South America	1	1

Source: Own elaboration

Finally, in order to evaluate the feasibility of different port-initiated measures according to relevant stakeholders, a workshop session was organized in Gothenburg, Sweden in June 2017 with 14 expert stakeholders, all with significant experience and expertise in the port sector. The participants included stakeholders representing three different ports, a forwarder, two research institutes and academia. The objectives of this workshop were to discuss five environmental incentives for inland transport selected from the 165 identified in the above review, analyse their feasibility from a stakeholder perspective and obtain a realistic assessment of their potential for real world application. Each participant was provided with an evaluation form for each of the five measures, and each

measure was discussed in four small groups during the workshop, with a minimum in each group of a researcher, a port agent and a shipper. For each measure, all groups had to indicate their opinion in relation to the defined criteria (the score was set according to a 4-point scale from low to high), as well as provide comments. A sample of the form is available in Appendix 1. The criteria used for evaluation were:

1. How big of an impact do you think this measure might have in terms of promoting more sustainable transport?
2. Would this measure gain industry acceptance?
3. How difficult do you think it would be to implement this measure?
4. Overall, how interesting is it to analyse this measure further?

From the 76 case studies, five examples were selected for presentation at the workshop based on the main goals described above: reduction of air emissions, reduction of noise, reduction of land congestion, modal shift and intermodal incentive. Table 2 summarizes the main characteristics of these five measures.

Table 2 Summary of specific case studies presented at the workshop.

	Five case studies based on main goals				
	Air emission	Acoustic emission	Land congestion	Modal shift	Intermodal incentive
<i>Port name</i>	<i>New York and New Jersey</i>	<i>Auckland</i>	<i>Los Angeles and Long Beach</i>	<i>Oakland</i>	<i>Rotterdam</i>
<i>Identification name</i>	Truck Replacement Program	Educational Efforts	Pier Pass Program: Traffic Mitigation Fee	Heavy Weight Corridor	Modal Split Obligation
<i>Application (design)</i>	Engine	Improve knowledge	Port dues and Subsidy fund	Dedicate Infrastructure	Concession Contract
<i>Type</i>	Incentive	Incentive	Incentive	Incentive	Incentive
<i>Environmental Concern</i>	Air emission	Noise	Air emission	Land congestion	Air emission
<i>Target</i>	CO ₂ emissions	Decibels	CO ₂ emissions	Planning	CO ₂ emissions
<i>Units of measure</i>	Engine	Vehicles	Containers	trucks	Containers
<i>Mode of transport</i>	Trucks	Trucks	Rail and Road	Trucks	Rail and Road
<i>Duration</i>	Since 2010	Not specified	Since 2005	Since 1993	Since 2015
<i>Area of action</i>	Port area	Port area	Port terminals	Port region	Port terminals
<i>Actors</i>	<i>Leader: Federal Congestion Mitigation and Air Quality Program and Diesel Emission Reduction Program</i>	<i>Leader: PA; National Road Carriers and the Road Transport Association New Zealand</i>	<i>Leader: State Government and Port Authority</i>	<i>Leader: Oakland City Council</i>	<i>Leader: Port Authority</i>

<i>Participants</i>	<i>Participants:</i> Port Authority and truck owners.	<i>Participants:</i> truck drivers	<i>Participants:</i> Carriers	<i>Participants:</i> PA, Public Works Department and the chief of police	<i>Participants:</i> terminal operators
<i>Incentives results</i>	Addition	Neutral	Addition	Neutral	Addition
<i>Brief description and comments</i>	Enables truck and fleet owners to invest in truck replacement with cleaner models. Up to 50 % of the cost of a replacement truck or a max of \$25,000.	Encourage truck drivers to eliminate noise from air braking at night	Night and Saturday shifts at both ports through the TMF during peak hours.	Roadways for the movement of heavy containers to have access to Port terminals.	Modal split obligation for the terminal operators

The first measure is located in the Port of New York and New Jersey. This initiative, called “Truck-replacement program”, started in 2010 and it aims to help port truckers replace older, higher-polluting trucks with newer ones with lower-emission engines (The Port Authority of New York and New Jersey, 2017).

The second measure, located in the Port of Auckland, has focus on applying educational programs in order to encourage truck drivers to eliminate noise from air braking at night. (The Port Authority of Auckland, 2017).

The third initiative is called Pier Pass Program and is located in the Port of Los Angeles and Long Beach. Since 2005, the objective of this program is to encourage port carriers to use additional shifts at both ports through a Traffic Mitigation Fee (TMF) during peak hours in order to reduce land congestion. According to the literature, extending gate time may result in higher operational costs for terminal operator or shipping line. Consequently, they would prefer daytime operation (Giuliano and O’Brien, 2008). In this specific case example, additional operational costs for extending the gate hours are compensated by using a congestion pricing model, a Traffic Mitigation Fee (TMF) is required for most cargo movement during peak hours. Consequently, the consignees are able to choose whether to carry the container in the daytime with the fee or at night without the fee. As a result, more than an average of 60,000 trucks per week have been diverted to the off-peak shifts (The Port Authority of Los Angeles and Long Beach, 2017).

The fourth initiative, located in the area of the Port of Oakland, aims to improve the movement of heavy containers from the city to the port terminals through the Heavy Weight Corridor. This modal shift permits to control that trucks do not use residential streets but instead specific truck routes in the city (The Port Authority of Oakland, 2017).

Finally, the last initiative is located in the Port of Rotterdam. Since 2015, the Port Authority has wanted to secure a modal shift through the contractual terms. The idea is to implement modal split obligations in the concession contract of the terminal operators with the aim to realize a modal shift towards rail and inland waterways (Van den Berg and De Langen, 2014). As a negative incentive, the port authority of Rotterdam introduced a penalty for tenants if they do not meet the modal split demanded by the port authority (Van den Berg, 2015; De Langen, 2008).

For the purpose of the analysis of the results, the mean, the median, the standard deviation as well as the frequency histogram have been calculated for each evaluation criteria. In order to interpret the results, scores close to 1 are considered as low/not at all, and those close to 4 are high/very.

Scores between these extremes were considered as “indifference”. The indifference reference value was 2.5. Table 3 summarizes the main results.

Table 3 Summary of the results based on the participants outcomes.

Evaluation criteria	Air emission			Noise			Land congestion		
	mean	median	Std. dev.	mean	median	Std. dev.	mean	median	Std. dev.
<i>Impact on sustainability</i>	3.3	4	0.8	1.7	2	0.6	2.3	2.5	0.8
<i>Industry acceptance</i>	2.4	2	1.0	2.7	3	1.2	1.9	2	0.9
<i>Difficulty to implement</i>	2.4	2	1.3	2.5	2.5	1.3	2.2	2	0.8
<i>Further analysis</i>	2.8	3	1.2	1.5	1	0.9	2.2	2	1.1

Evaluation criteria	Modal Shift			Intermodal Incentive		
	mean	median	Std. dev.	mean	median	Std. dev.
<i>Impact on sustainability</i>	2.5	3	1.0	3.0	3	1.0
<i>Industry acceptance</i>	2.8	3	1.1	2.6	2.5	0.9
<i>Difficulty to implement</i>	3.2	3	0.8	2.3	2	1.0
<i>Further analysis</i>	2.3	2	0.9	2.5	2	1.0

Source: Own elaboration based on the workshop outcomes

According to Table 3, the main results suggest the following outcomes. Firstly, it seems that the reduce air emission program, modal shift and intermodal incentive have higher impact on sustainability. In contrast to the reduction of noise emission plan and the land congestion measure. Secondly, from industry acceptance point of view, only the reduction of noise plan and the modal shift incentive would gain their approval. Thirdly, all measures would be difficult to implement, except for the case of reduction of air emission plan. Finally, key stakeholders considered that only the air emission incentive would be interesting to analyse for further research. Following, a more precisely analysis from the results of all five case studies are described.

The first measure, applied in the Port of New York and New Jersey, has focus on rebate for trucks with cleaner engine. Firstly, it seems that this measure has the highest expected impact on enhancing sustainability. Thus, this impact would be focus on cleaner trucks that move to and from the port. Furthermore, this measure could have more impact if there is a specific fast lane for vehicles with low environmental footprint. Secondly, it seems that industrial acceptance would be lower acceptance due to it depends on the design as well as a new fee system which to give rebates. Thirdly, all participants considered that this incentive is not too difficult to be implemented. However, it is important to implement it in many ports at the same time to avoid discrepancy in the competitive

among the ports and take into account some technical standards. Finally, the participants consider that it would be of value to continue with further analysis.

The second measure were applied in the Port of Auckland and offers an educational program to encourage truck drivers to eliminate noise from air braking at night. Based on the key stakeholders' opinions, this measure seems to be easy for an industry acceptance however the relevance is weak due to the fact that there are not many residents close to the ports in Sweden and when ports evaluate noise, ships and trains are often more relevant than trucks. A possible application could be raising awareness on loading and unloading operation, which primarily requires technical measures on ramps, bridges or equipment.

The third measure, applied in the Port of Los Angeles and Long Beach, aims to implement a payment of Traffic Mitigation Fee during peak hours at terminal gates. According to the evaluation, the impact on sustainability seems indifference. On the one hand, it depends on the city and the type of ports. Besides, this measure implies a reduction of queues, which could be effective because it entails less congestion and more efficient traffic. On the other hand, traffic flow or congestion depends on the schedules of the ships. Second, the participants consider that the industry would not really accept this measure, since it depends on the demand and on traffic. Third, it seems that the implementation would not be difficult for the industry. In this regard, this measure requires parking space and implementation of new fees.

The fourth case study is located in the Port of Oakland, where a specific Heavy Weight Corridor is designated for the movement of containers from port region to port terminals. First, all participants consider that the impact on sustainability is high. This measure could be interesting for ports with high local traffic congestion, so the impact would be in the local areas. Secondly, it seems that the industry would accept this measure as long as it is possible to reduce congestion and time. However, it is up to the market to decide which mode of transport to choose. Thirdly, the participants consider that it is difficult to implement this measure. It would greatly depend on who is covering the costs of the implementation, since this measure has a lot of money involved. The costs depend on whether the ports have the infrastructure, or it needs to be constructed. In the case of Swedish ports, it might be difficult to implement it because there are not too many alternative routes. In this regard, it would be necessary to form a larger traffic plan and specify clearly who would build and fund the project. The scenario could be designed using the EcoBonus system, for example, in a scenario where there is a logistic partner closer to the port with private infrastructure and with longer trucks.

Finally, the last initiative is in the Port of Rotterdam, where the modal split minimal limits are controlled by the concession contract and exceeding these limits generates penalties for the terminal operating company. Firstly, it seems that the impact on sustainability would be high. Thus, to make an even greater impact, it would be a good idea to introduce this measure not only for the environment but also as a Corporate Social Responsibility (CSR) strategy. Nevertheless, the participants raise the question of road electrification. Thus, in the future, it might become questionable whether railway and inland waterways are better alternatives to road. Secondly, it seems that the industry would be indifferent to the acceptance. It would depend on the cost and expectations, and not on demand. In this regard, it should be included in the environmental permit. Thirdly, from the outcomes, it seems that this plan is not difficult to implement. Determining the decision makers and the funding agents would be the most difficult. This would depend on the terms in the contracts, which are signed for long term. Besides, due to not all ports have rail tacks, this measure could be limited to implement. Stakeholders consider an interesting field for governance studies.

2.1.3 Conclusions

The current growth in freight traffic has challenged the distribution of goods through intermodal transport chains in the port area. Within this context, ports are focus on improving their hinterland connection in order to guarantee their traffic and competitive position. Consequently, the intermodal transport network has an effect on the environmental impact of hinterland distribution of cargo. In this regard, it is relevant to study how ports can internalize environmental externalities and promote sustainable transport solutions through different strategies.

This present framework aims to identify incentives and fees established by ports in order to improve the environmental performance of its connecting transport network, with focus on hinterland logistics. At the same time, this study permits proposed measures based on effect and feasibility from the analysis of real case studies.

Through an analysis of data collection on different case studies around the world, 76 cases and 165 incentives have been identified. Thus, in order to analyse and homogenize all different case studies, it has been conducted a criterion based on the objectives and the application of the incentives established by ports. In this regard, this research has scientific value due to it is one of the first and most comprehensive mapping of port initiatives incentives and fees related to sustainable transport from a hinterland perspective.

From the results, the most common objectives are modal shift incentives through a dedicated infrastructure, reduction of air emissions from engines, as well as monitoring programs and reduction of land congestion applying technology services. In contrast, knowledge improvement, and the application of port dues and subsidy funds are the least common designs. However, while a system of measures is a promising tool for improving the environmental and social performance of transportation systems, this is not a sufficient criterion for a solution to be successfully implemented. Equally important is how different actors perceive the tool and how it influences relations between actors in the transportation system. In this regard, it has been analysed five specific case studies from a Swedish perspective with the help of key stakeholders.

The results from the workshop session suggest the following outcomes. Firstly, air emissions measure, modal shift and intermodal incentive would have higher impact on sustainability. In contrast, the reduction of noise emission incentive and the reduction of land congestion plan would have lower impact on sustainability. Secondly, key stakeholders considered that only the reduction of noise incentive and the modal shift incentive would gain industry acceptance. Thirdly, except for the case of reduction of air emissions, the rest of measures would be difficult to implement. Finally, the air emission incentive would be interesting to analyse for further research.

2.2 Sea transport

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2.2.1 Introduction

The environmental performance of shipping can be evaluated in many ways. There are currently a number of indexes and incentive schemes active that offer lower port dues or better marketing opportunities, but there are differences in which parameters are prioritized and valued. When performing an inventory Svensson and Andersson (2011) found 38 different environmental performance initiatives focused on the shipping industry. Out of this, 10 indexes were selected for further study based on different characteristics of the indexes or incentives. The project CleanShip from Clean Baltic Sea Shipping found 50 initiatives for a possible port dues differentiation scheme. In the final report of CleanShip 14 initiatives were singled out (CleanShip 2017). In this chapter, the indices and incentives connected to shipping are mapped and evaluated.

2.2.2 Methodology

This chapter describes the methods and work flow of this study which is elaborated from the methodology earlier used by Svensson and Andersson (2011). The study was conducted in four phases:

- 1) Inventory of environmental performance initiatives
- 2) Identification of relevant indices or incentives and selection for further study (presented and discussed at reference group meeting)
- 3) Selection of indicators for further analysis in the MAI project (checking if the most suitable indicators have been chosen)
- 4) Evaluation of feasibility for usage for Swedish ports

Inventory of initiatives

The inventory of initiatives is based on literature review, where the earlier mentioned studies of indexes and incentives have been further studied.

Identification of relevant indexes or incentives and selection for evaluation

In the CleanShip study, the focus was to find possible indexes or incentives for ports to use in the Baltic Sea area as a port dues differentiation scheme, which is similar to the purpose of this study. The prerequisite for an incentive in the CleanShip study was that the focus should be on environmental issues most relevant to a port, not be coupled to a single class society and address the main types of ships in the ports. This prioritization is also relevant to this study; however, the aim is on all environmental issues in the port. In the Svensson and Andersson study of 2011 the next step was to evaluate whether or not the initiatives were environmental indexes or not. This question is not relevant for this study as the purpose is to measure the environmental impact of any incentive – no matter if it is defined as an index or not. The basis for selection of relevant incentives or indexes in this study are:

1. whether or not methodology is publicly available
2. whether or not ports can have access to the performance data (either as members, pay a fee or publicly available)

3. whether or not the incentive or index includes the main types of ships calling in the port
4. if the index is related only to a single class society
5. whether or not the incentive or index is relevant for Swedish ports. Relevance is judged by:
 - a. implementation possibilities for Swedish ports
 - b. level of administration needed for port authority
 - c. *if the incentive or index is currently used by a port*

Selection of indicators

A compilation of the environmental impacts of the selected indices were performed and are included in Table 4. Information on the selected indices, indicators and schemes are conglomerated into four sections are provided in Chapter 2.2.3.

Evaluation of feasibility for usage for Swedish ports

In order to get a picture of which indicators and indexes that are used today, a desktop search was performed including all ports which are members of the organization Swedish ports. Further, for each incentive possibility or measure was discussed during a workshop with the reference group in smaller groups evaluated in a form. There was also a possibility for further personal comments to the project group. For each incentive possibility, the group's joint opinion was written down. The criteria used for evaluation are:

- How big impact do you think this measure can have in terms of enhancing more sustainable transport?
- Would this measure gain industry acceptance?
- How difficult do you think this measure would be to implement?
- Overall, how interesting is it to analyse this measure further in the project?

2.2.3 Inventory, selection and presentation of indices

There are differences between index, indicators and incentives. An indicator could be any group of statistical values that taken together give an indication of the health of the environment (Merriam-Webster, 2017). It could for instance be a group of statistical values or a statistical value (such as the amount of NO_x emission per kWh) that give an indication of the level of pollution in an area over a period of time. An index often contains a set of indicators. An incentive is when an indicator is connected to a monetary value. For instance, a certain lowered emission of NO_x equals to a certain lowered port dues or other cost that the vessel or ship operator has when calling at a port.

Inventory of initiatives

As seen in Figure 3, most of the indices are located in Europe, but actors in North America and Asia have also developed differentiated fees and incentive structures.



Legend - figure 1

- Indices
- 📍 Indicators/incentives

Source:

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<https://commons.wikimedia.org/w/index.php?curid=31996181>

Figure 3 World map with location of all indexes and incentive schemes marked. Own elaboration based on desktop study.

Identification of relevant indexes or incentives and selection for evaluation

The selected indices for this study can be seen in Table 4. A compilation of the environmental impacts of the selected indices can be seen in Appendix 2.

Table 4 Selected indices and incentives.

Index or incentive scheme	Activity (number of vessels)	Short description of scheme	Source
The Blue Angel RAL-UZ 110	Active (1)	A whole range of emissions to both air and water, plus focus on environmentally friendly ship operation.	Blue Angel Criteria, 2017
The Carl Moyer program	Active (unknown number of vessels)	The program provides grant funding for cleaner-than-required engines and equipment focused on NO _x emissions, PM and reactive organic gas. Local air districts in the US administer grants and select which projects to fund.	
Clean Shipping Index	Active (2,231)	Emissions to air (such as CO ₂ , NO _x , SO _x and particles), chemicals used on board (such as antifouling, oils/fluids, cleaning agents and refrigerants) and emissions to water (such as sewage, grey water, sludge, bilge, and garbage)	Clean Shipping Index, 2018
Environmental Ship Index	Active (5,497)	Emissions to air such as CO ₂ , NO _x , SO _x	Environmental Ship Index, 2017
Green Award	Active (256)	Environmental effects such as emissions to air and water, health safety and security for the crew	Green Award, 2017
Green Flag incentive program	Active (3938) ²	Speed reduction incentive	Port of Long Beach, 2017

² Number of compliant legs year 2016

Green Marine Environmental Program	Active (500)	Programme includes indicators such as invasive species, air emissions (SO _x , PM, NO _x , greenhouse gases), cargo residues, bilge water, garbage management and underwater noise	Green Marine, 2017
Green Ship Incentive program	Active (unknown number of vessels)	Reduction of smog-causing nitrogen oxides (NO _x)	
Maritime Singapore Green Initiative: Green technology program	Active (unknown number of vessels)	Verifiable reduction of SO _x , NO _x , CO ₂ that comply with industry performance guidelines, should not be commonly deployed in the maritime industry and be type-approved. Installation must be done in Singapore.	

Presentation of selected indexes

After the overall mapping of indexes nine indexes, indicators and incentive schemes were selected for further analysis. The selected ones are presented shortly below.

The Blue Angel (RAL-UZ 110)

The Blue Angel (RAL-UZ 110) is an environmental label for ship operation. It is created by the Environmental Label Jury which governs the Blue Angel label and includes representatives from different stakeholders such as environmental associations, consumer associations, trade unions, German industry representatives, local authorities, academia, German media, churches, youth representatives and the German federal states (Blauer Engel, 2017). There are no geographical boundaries to the index. Tank ships, fishing vessels as well as sport boats and navy ships are not included in the index (Blue Angel Criteria, 2015). Included environmental impacts are emissions to air such as CO₂, NO_x, SO_x, PM/BC, energy efficiency, antifouling paints, oils in stern tubes, gears and other hydraulic fluids. Chemicals such as cleaning agents, refrigerants must be environmentally adapted. Impact emissions to waters such as ballast, sewage, sludge, bilge and garbage management are included. Also monitoring of noise, underwater noise, environmental management systems, environmentally friendly ship design, hull stress monitoring, emergency towing system, onshore power supply and ship recycling are rewarded through the system (Blue Angel Criteria, 2015).

The Carl Moyer Program

The Carl Moyer Memorial Air Quality Standards Attainment Program (Carl Moyer Program) aims to lower emissions of nitrogen oxides (NO_x), particulate matter (PM), and reactive organic gas (ROG) (California ARB 2, 2017). The program was started to improve the ambient air in the state of California (California ARB 1, 2017). For marine vessels there are two different incentives under the Carl Moyer program. Vessels can get support funding (50-85% of cost) when replacing an old engine with a new with lower emissions, retrofit with new technology or switch to a low emitting vessel. At berth, vessels can get support funding (50-100% of retrofit cost) for turning off auxiliary engines and connecting the vessel to some other source of power, most likely grid-based shore power or use alternative control technology that achieve equivalent emission reductions. Vessels are only eligible when trafficking Californian waters or calling at Californian ports. A vessel is eligible for the program if it meets the Tier II or Tier III of the MARPOL Annex VI NO_x emission limits (California ARB 2, 2017).

The Clean Shipping Index (CSI)

Clean Shipping Index (CSI) is a tool to single out clean ships. Ship-owners present the environmental profile of their fleet to a network of stakeholders such as cargo owners, ports, forwarders and maritime technology providers. The board of the organization consists of representatives from Swedish cargo owners, the Swedish Maritime Administration and Port of Gothenburg (Clean Shipping Index, 2017). Carriers can apply for a log in to the internet-based Clean Shipping Index database, where 25 questions for each ship are answered based on the shipping company's environmental performance. Carriers can then choose to verify this data by using a third-party verifier. There are no geographical boundaries to the index and most ship types are able to add data to the index. Included environmental impacts are both emissions to air and water, waste management and education of personnel, which can be seen in Appendix 2. Ships receive scoring depending on the environmental performance beyond regulatory compliance (Clean Shipping Index, 2017). The ships can become certified and depending on the scores received a one to five-star certification is rewarded, where one star is the lowest scoring and five is the highest scoring (Clean Shipping Index, 2017). To become certified a number of documents must be reviewed by the class societies which is stated in the verification guidelines (Clean Shipping Index, 2017). The index shares methodology and verification procedure openly but does not publish certified vessels on their website.

The Environmental Ship Index

Environmental Ship Index (ESI) is an index focused on reducing emissions of NO_x, SO_x and particulates, as well as including CO₂ reporting. ESI was started by the World Ports Climate Initiative in the year 2011 (Environmental Ship Index, 2017). This initiative was developed by the International Association of Ports and Harbors (IAPH) and day-to-day business connected to the ESI is done by the ESI bureau of IAPH. Ship owners can answer general information about their ships and also give specific information about the engines onboard, data on fuels used, emitted CO₂ and if the vessel has technology on board to use On Shore Power Supply (OPS) to the ESI database (Environmental Ship Index, 2017). The ESI bureau checks reported data and have systems in place to check for inconsistencies and obvious mistakes. If high ESI score is obtained for a vessel, ship owners may be asked to supply ESI bureau with copies of Bunker Delivery Notes (BDN). Included environmental impacts are emissions to air, namely SO_x, CO₂, NO_x, and particles (PM/BC) and there are no geographical boundaries to participating as a ship owner or a port (as an incentive provider) (Environmental Ship Index, 2017). Scoring in the ESI system are based on emissions of NO_x, SO_x (and particles), CO₂ and if the vessel has the ability to use Onshore Power Supply. A ship that scores in the ESI system must have emissions lower than the legal requirement for NO_x and SO_x. The ESI score is capped at 100.

The Green Award

Green Award is a certification system focusing on safety, security and environmental issues. Green Award rewards high safety and environmental standards in shipping and makes above standard ship operation economically more attractive through a number of incentive providers, both ports and others (Green Award, 2017). There are no geographical boundaries to the certification scheme and oil tankers, chemical tankers, dry bulk carriers, LNG, LPG, container carriers and inland navigation vessels can participate in the scheme (Green Award, 2017). Included environmental impacts are emissions to air such as SO_x, NO_x, CO₂, particles (PM/BC) and questions regarding energy efficiency, antifouling paints, oil in stern tubes, mooring wire lubrication and other deck equipment. Impact emissions to waters such as ballast, sewage, sludge, bilge and garbage management are also included. Scoring is also achieved for having a company policy that vessels due for recycling will only be sold directly to a recycling facility and that the ship owner or manager has to audit a recycling facility before signing a "contract of sale" (Green Award, 2014). The Green

Award requirements consist of three parts. They are *basic* requirements such as statutory elements related to regulations as ISM, MARPOL, *ranking* requirements where there is a minimum percentage to be attained and a *visual inspection* making sure the ship is seaworthy and that the documentation is structured and well-organized (Green Award, 2017).

The Green Flag Incentive Program

The Green Flag Program is a voluntary vessel speed reduction program that rewards vessel operators for slowing down to 12 knots or less within 40 nautical miles (nm) of Point Fermin (near the entrance to the port of Long Beach). The result is reduced smog-forming emissions and diesel particulates from ships. If the vessel operators have a 90% compliance rate, they can earn dockage rate reductions, as well as help improve air quality in the greater Long Beach area. The speed of every vessel in the speed reduction zone is measured and recorded by the Marine Exchange of Southern California. The program prevents more than 1,000 tons a year of air pollution (Port of Long Beach, 2017).

The Green Marine Environmental Program

Green Marine is an environmental program for many parts of the marine industry. The organization markets itself as “a voluntary, transparent and inclusive initiative for the North American marine industry” (Green Marine, 2017). The initiative has a broader focus than the abovementioned indexes as ship owners, ports, Seaway corporations, terminals and shipyards can participate. The participants have to improve their environmental performance each year to maintain certification. The result is a ranking for each performance indicator on a 1-to-5 scale. Level 1 constitutes the monitoring of regulations, while Level 5 indicates leadership and excellence (Green Marine, 2017). The board of directors consists of US and Canadian company CEO’s and presidents. Besides this, members, industry stakeholders, environmental groups and legislators are organized in three advisory committees representing the St. Lawrence region, the Great Lakes and the West Coast who provide input and advice on different aspects of the development of the Green Marine program (Green Marine, 2017). Ship owners need to fill in a self-evaluation form in an interactive Adobe Reader document which includes 11 different environmental performance indicators. There are different questions depending on if the ship owner is domestic or an international operating ship owner. The participants will be ranked according to the answers given in the evaluation – from level 1 (lowest performance) to level 5 (highest performance). The ships must be verified according to a third party every two years. The participant agrees to have its ranking results published each year (Green Marine, 2017).

The Green Ship Incentive Program

The Green Ship Incentive Program is an initiative targeting the reduction of nitrogen oxides (NO_x). Vessels with main engines meeting 2011 Tier 2 standards established by the International Maritime Organization (IMO) are eligible for an incentive of \$2,500 per ship call. For still cleaner vessels meeting 2016 Tier 3 standards, the incentive will increase to \$6,000 per ship call. Tier 2 engines reduce NO_x emissions by 15 percent, and with Tier 3 engines, emissions will drop dramatically by 80 percent (Port of Long Beach, 2017).

Maritime Singapore Green Initiative: Green Technology Program

The Green Technology Program provides grants of up to 50% of total qualifying costs to co-fund the development and adoption of green technologies. Grants are capped at 2 million Singapore dollars per project. The grant is limited to two successful applications per company per year. All projects need to result in a verifiable reduction of air emissions (either SO_x, NO_x, CO₂), should be a new technology in the maritime industry, type-approved and installation, integration, design and retrofitting should be done in (MPA Singapore, 2017).

Selection of indicators for further study

The indices all contain different indicators in order to evaluate the environmental performance of ships, see further Appendix 2. Ports can either choose to use the indices as a whole or take one or a couple of indicators to use as incentives. For the continuation of the work in the project, four indicators were selected for further discussion and evaluation during an expert elicitation in the MAI reference group, see Table 5.

Table 5 Indicators from indices chosen for expert elicitation and the usage within indices and incentive schemes.

Index/Indicator	The Blue Angel	CSI	ESI	Green Award	Green Marine Environmental Programme	Maritime Singapore Green Initiative: Green Technology Programme
CO ₂	X	X	X	X	X	X
NO _x	X	X	X	X	X	X
PM / BC	X	X		X	X	
OPS	X	X				

Besides these indicators, researchers wanted to see if an incentive program similar to the Green Flag Program would be possible to implement in a Swedish perspective. Slow steaming is an interesting indicator to evaluate as it is an operational measure with low investment cost and can be applied to any ship (Eide et al., 2011). Ways to keep CO₂ emissions from ships lowered could be regulated speed restrictions (Faber et al., 2012) or port rebates for slow steaming in fairways. The latter is a measure that would not interfere with international regulations (Styhre and Winnes, 2016). Thus, this measure was also selected for further analysis.

The following indicators were selected for expert elicitation during the workshop with the MAI reference group:

1. Port dues related to emissions of NO_x

The port dues incentive or rebate system could either be similar to the system earlier used by the Swedish Maritime Administration with a stepwise incitement with higher weight of auxiliary engines or if emissions are lower than the Tier II or Tier III of the MARPOL Annex VI NO_x emission limits.

2. Port dues related to emissions of CO₂

The port dues incentive or rebate system could either be similar to indicators in indexes such as Environmental Ship Index (ESI) or Clean Shipping Index (CSI) or possibly only related to type of fuel used.

3. Port dues related to emissions of particles (PM)

The port dues incentive or rebate system could either be similar to indicators in indexes such as Clean Shipping Index (CSI) or possibly related to type of fuel used or abatement techniques such as filters.

4. Port rebate related to connection to Onshore Power Supply (OPS)

Ships would receive rebate when connecting to OPS when calling in a port.

5. Port rebate related to slow steaming in fairways

A rebate is received for reduced speed close to the port city (for instance from the pilot boarding point or a certain distance from the port).

2.2.4 Evaluation of selected incentives in workshop with the reference group

The selected incentives were then evaluated in the reference group. The experts were divided into groups to discuss the different incentive possibilities, and an evaluation form was used, see Appendix 1. As described in Chapter 2.1.2, the participants were asked to interpret the results. The results from the quantitative part of the exercise are presented in Table 6. Values are the average value from twelve participants' individual scoring. Also included are conclusions for each measure.

Table 6 Evaluations of five potential economic instruments that ports can use to promote ships with high environmental performance according to a 4-level scale. 1= Low/Not at all; 4 High/Very.

Instrument	Criteria	Value (1–4)
1. Environmental differentiation of port dues related to measures to reduce NO_x emissions.		
	Environmental potential	3.3
	Industry acceptance	3.3
	Difficulty in implementation	2.2
	Further analysis	2.9
Highest expected industry acceptance; Expected to be the instrument that is easiest to implement; High expected impact on sustainability		
2. Environmental differentiation of port dues related to measures to reduce CO₂ emissions.		
	Environmental potential	3.0
	Industry acceptance	2.3
	Difficulty in implementation	2.3
	Further analysis	2.8
Lowest expected industry acceptance		
3. Environmental differentiation of port dues related to measures to reduce particulate (PM) emissions.		
	Environmental potential	3.3
	Industry acceptance	2.4
	Difficulty in implementation	2.8
	Further analysis	3.0
Most interesting for further analysis; Expected to be the instrument that is most difficult to implement; High expected impact on sustainability		
4. Discount on port dues for ships connecting to the land-based power grid when at berth.		
	Environmental potential	3.7
	Industry acceptance	2.8
	Difficulty in implementation	2.4
	Further analysis	2.7
Highest expected environmental potential		
5. Discount on the port dues for ships that slow down in the fairway channel.		
	Environmental potential	2.8
	Industry acceptance	2.8
	Difficulty in implementation	2.4
	Further analysis	2.4
Lowest expected environmental potential; Least interesting for further analysis		

Generally, it can be said that some reflections from the expert elicitation shows that they are general; not depending on the measure itself. For instance, when it comes to the effectiveness of the measure, it can depend on how many ports use the same rebate and abilities to reduce port dues. This is very important for the measure Onshore Power Supply (OPS). A vessel that runs in a liner service and only can benefit in one of the ports cannot be expected to invest in OPS. However, if the vessel is able to connect in all ports, this might be a feasible option. A small port quite dependent on its clients could have great difficulties to implement a port due reduction scheme. Generally, it can also be said that a rebate is easier to implement than fees according to the experts.

Results show that port dues related to **emissions of NO_x** have the highest industry acceptance and are also expected to be measure that is easiest to implement. This is an expected result as the fairway dues have been based on emissions of NO_x and ports have also based their environmentally differentiated dues in Sweden on NO_x emission since the 1990's. Consequently, the indicator is not considered to be relevant for further analysis. However, some groups thought it interesting to investigate effects of NO_x emissions after the regulation on NO_x emission control area in the Baltic Sea has been implemented. As this regulation only will be implemented on new vessels from 2021, there is a risk that the regulation will be counteractive. The experts identified a problem that older vessels could be moved to the Baltic Sea in order to avoid additional technical requirements on the ships. A rebate for lower NO_x emission would then support a continued lowered emission of NO_x in the region. The experts also identified a risk that the technology needed to lower NO_x emission is quite expensive, which would entail that rebates must be substantial to get the needed effect, or rebates need to be differentiated and long-term so that it generates investment from the ship-owners. A way to get around this could be to introduce a Bonus-Malus system where it is more expensive for high-emitting vessels and cheaper for cleaner vessels.³ In order for the measure to be effective there needs to be a control mechanism in place as the certificates from the Swedish Maritime Administration will be taken away.⁴

The port dues related to **emissions of particles** is regarded by the groups as the most interesting measure for further analysis but is also expected to be the most difficult measure to implement. Experts commented that this is an important issue to address for ports located in residential areas as health aspects and particles are getting increased focus. Available technology was considered an obstacle, while some argued that filters exist and are already in place on some car carriers. Still some argued that lack of standards makes the issue new and difficult for the shipping industry.² The experts identified liner service vessels as the ship type that would be most suitable for this measure, because of the operational patterns.³

A port rebate connected to **Onshore Power Supply (OPS)** is considered by the expert groups to give the most positive impact on sustainability of the five selected indicators. In the group discussions the experts state that the measure has the most potential as it lowers all emissions to air and noise. This measure is easier for existing vessels calling on the port, than new clients and vessels with long time in port (as to vessels with short turnaround time). That the usage of OPS goes slow is considered a matter of price, not a technical issue as the technology is expensive to invest in and to run. Discussions on the negative side for carriers that have invested in OPS as it is more expensive to run on electricity than fuel, and in Sweden an "effect fee" is added, which is several SEK/kWh. In the group discussion on of the group of experts wanted to investigate which ports would have the most effect of an introduced measure on OPS.² "OPS should be compulsory for new-buildings" and "connection fee is too high" where some of the individual comments worth mentioning.³

³ Taken from notes of the group discussions.

⁴ Taken from individual comments.

The **measure related to CO₂** might not be considered too interesting for ports as it is a global problem resulting in global warming and not a local issue, as local health. However, some ports prioritized this measure high and wanted it on the agenda as a measure to be able to give rebates to vessels that performed well in this category of emissions. Implementation was considered relatively easy by the experts as energy efficiency is already in focus by the ship owners in order to reduce costs for fuel and that the MRV regulation will show how emissions should be calculated and reported to the EU. It was also discussed if this would be a real carrot for the ship owners that really need to improve or just “a pat on the shoulder” for those already doing well in this category.² The individual comments reported by the experts was a discussion on if the rebate would be effective, if instrument would calculate on whole sea-leg or only close to the port, and that it need to be differentiated on ship types. There was also a differentiation in the answers as some thought this instrument could have a big impact globally and some thought it would not have any impact at all.³

When it comes to **slow steaming approaching port areas**, the impact on sustainability was considered small as fairways are generally a short distance. When it comes to industry acceptance, this depends on type of shipping segment. It could be difficult for liner services with fixed time tables. Generally slow steaming should be done as a part of a fuel savings program by the ship owners. If this indicator were to be selected for further analysis, then full journeys should be considered in order to avoid that speed reductions in fairways are compensated by full speeds at sea. This would counteract positive environmental effects. One of the expert groups concluded that it should be included in the fairway due rebates instead of port dues, as ports should not give rebates on areas not included in the port areas.² In the individual comments, experts concluded that all ships should lower speed in the fairway to be able to lower emissions from all vessels – not only those who decide to participate in a port program.

2.2.5 Inventory of used indices and indicators in Swedish ports

In order to get a picture of which indicators and indexes are used today, a desktop search was performed in spring/summer 2017 including all ports which are members of the organization Swedish Ports. The website of the port was visited and if there was no information found on incentives or indices, the port was contacted by email or phone to check if a port incentive was used for the vessels calling at the port. This work was done during September 2017 with an update during May 2018. In the latest update of the desktop study 37 ports was included in the research. Out of the 37 ports in Sweden 16 ports have no incentives, 19 ports have incentives and 2 ports did not respond. The 19 ports that have an incentive for ships calling at the port can be seen in Table 7 below.

Both Port of Gävle and Port of Gothenburg have chosen a combination of the indices Environmental Ship Index and Clean Shipping Index to give rebates on port dues. In order to get a 10 % rebate on port dues based on GT, ships need to be rewarded five stars in CSI or have received 30 points in the ESI system (Port of Gothenburg, port of Gävle, 2018). Port of Sundsvall has chosen to give rebates of 10% if ships reach 30 points in Environmental Ship Index (Port of Sundsvall, 2018). When it comes to NOX emission, the general discount from the Swedish Maritime Administration is the basis for the discount for these ports. The level of rebate differs, but the levels of emission which results in rebates are similar. When it comes to usage of LNG, rebates differ from 5 öre/BT to 15 %-40 % rebate on the port dues based on GT. Rebates based on Onshore Power Supply differ from 1 million SEK to 40% of the port dues based on GT.

Table 7 Ports in Sweden and their use on indices or indicators for incentives (mapping carried out in spring 2017).

Port	Environmental Ship Index/Clean Shipping Index combination	Environmental Ship Index	NO _x emission	LNG usage	Onshore Power Supply usage	S emission
Falkenberg			X			
Gävle	X					
Göteborg	X			X		
Hargshamn			X			X
Helsingborg			X			
Luleå			X			
Mälarhamnar			X			
Norrköping			X			
Piteå			X			
Skellefteå			X			
Stockholm ⁵	X			X	X	
Sundsvall		X		X		
Södertälje			X			
Sölvesborg			X			
Uddevalla			X			
Vänerhamn			X			
Wallhamn			X			X
Ystad			X	X	X	
Åhus			X			

⁵ Ports of Stockholm introduced environmental discounts based on Clean Shipping Index in 2019 and abandoned the old NO_x rebate system.

3. Environmental and energy analysis of road and sea transport

This chapter includes the analysis of the expected environmental impact of two incentives for land transport and two for sea transport, including uncertainty and sensitivity analysis for sea transport. At the end of the project, all reference group members were interviewed individually, so they could give their general opinion about environmentally differentiated port dues and the results. A summary of the interviews is found in this chapter.

3.1 Environmental analysis of incentives for inland transport

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3.1.1 Background

Historically, the harbour has been an integral part of the port city and road traffic to and from the coast has been seen as a natural part of the city's business community and thus always gained a priority in traffic and urban planning. In line with the development towards larger cargo vessels port terminals have met up with longer quays, deeper sailing depths and more land areas for cargo storage and handling in the vicinity of the quays. This development has meant that many port terminals have moved further out in the fairway or towards the open water, while the cities have continued to grow behind and around the port terminal. With this development the goods no longer need to be unloaded in the central parts of the city, instead freight transports can utilize the track and road capacity built from the port through and around the city. This development occurred in many cities between the 1950s and until present days. At the same time, truck traffic has developed to become the dominant solution for land-based freight transport to and from ports, this at the expense of the railways and inland water ways. As cities continue to grow in populations, housing and business buildings have claimed past industrial land and 'poorer' lots near different types of industrial activities, such as ports and other logistics operations. In this way the city's built up areas have been forced closer to road and rail corridors used for freight traffic to and from the port. Together with increased freight volumes this has led to a situation where road freight in many places' conflicts with the city's ambitions to grow and develop.

In environmental assessments of port operations, demanded by law in Sweden, the environmental courts have in most cases considered that the port operator is not in control of how land transport is carried out. Thus, port-related freight traffic on the road network has not been affected by restrictions on e.g. noise, emissions and traffic times. Road traffic to and from Swedish ports is thus not regulated by other means than all other traffic on the roads that pass through the urban areas of port cities. As an effect of this, the state of knowledge about how these transports are carried out is inadequate. Few studies exist where, except for single measurements, one tries to investigate the road logistics set up, e.g. by examining the starting point and the target point, the number of traffic movements, the route through the urban area, the time of the transport, the truck's environmental class, the load capacity and the amount of cargo loaded.

In summary, road haulage through urban areas is today governed only by standard traffic rules i.e. in terms of transport of dangerous goods, weight restrictions, cargo security, speed limits, congestion charges, and driving and rest periods.

The purpose of this chapter is to describe potentials to reduce today's environmental impact from road freight traffic to and from port terminals. The above-mentioned lack of detailed knowledge motivated the completion of new traffic and cargo measurement. The purpose of the measurement is to produce a data from which the current environmental performance can be calculated and potentials for improvements can be explored.

3.1.2 Choice of ports

Truck traffic to and from the container terminals in Gothenburg and Stockholm's ports were selected for a more detailed study. The motivation not to study the Trelleborg port further (which is also part of the project) was based on the fact that the shipping traffic in Trelleborg is dominated by RoPax traffic and lorries' arrival and departure times are closely linked to the ferries' timetables (little opportunity to control transit traffic in time) and that trucks often accompany the cargo on the ferry (i.e. not only separate trailers). The transport is then usually included in an international traffic where driver costs are important in time-price balances. Furthermore, the ferries are looked upon as a part of the European road network, why the possibility of regulating vehicle access to the terminal was judged to be extra problematic from a legal perspective. This, together with an ongoing project with a new entry/exit road route, makes it less likely that port gate fees are appropriate, less possible, to be introduced in Trelleborg in a manner that may affect the truck traffic.

As regarding the Port of Gothenburg, we defined the study into a more detailed traffic analysis for the container terminal. Every year, the container terminal (Skandia Harbour) handles approximately 800 000 TEU. For the detailed analysis, we limited the study to truck traffic to and from the container terminal. This investigation builds on the previous study of lorry traffic carried out during one week in the autumn 2015. By interviewing drivers at the ports to the terminal were driving routes through the urban area, the age of vehicles and the drivers' nationality investigated.

For the Ports of Stockholm, the container terminal in Frihamnen was chosen as a study object. In the terminal, 60 000 units are managed annually, of which a majority is transported by road.

As a basis for a potential assessment, an analysis of today's road traffic was conducted at the studied port terminals. The analysis was based mainly on observations made at the entrance gates to the terminal (e.g. vehicle registration number, cargo load capacity (as TEU-positions), number of TEUs loaded), supplemented by data from port terminal systems (cargo weights and destinations) and from the public vehicle register (e.g. age, fuel type, engine Euro class, max curb weight).

3.1.3 Ports of Stockholm – present road traffic

Case description and methodology

The freight transports by road to and from the Ports of Stockholm container terminal was investigated by a traffic and cargo counting at the combined in- and outbound gate, see 'x' mark in Figure 4 below. The field study was done in the morning of April 14th, 2018 between 05:00 and 08:30. A total of 75 observations were made of in- and outgoing traffic.

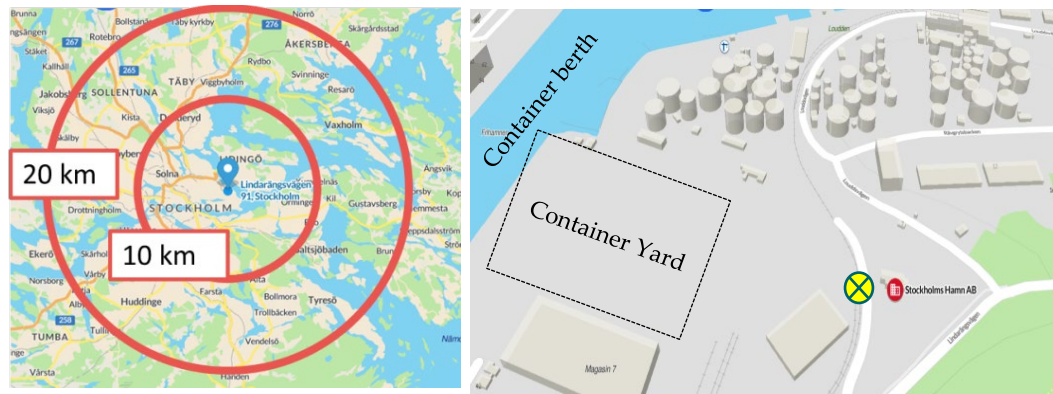


Figure 4 Stockholm Container Terminal, location in the Stockholm region and terminal layout.

Results and discussion

The data collected at the field study was combined with load and destination data obtained from the port internal booking system. The following facts regarding the road traffic were calculated, see Table 8.

Table 8 Results from observations at Ports of Stockholm container terminal, April 2018.

		Incoming	Outgoing
No. of observed vehicles		39	36
Load capacity, total all vehicles	TEU-positions	77	71
No. of carried TEU	TEU	41	52
Average load capacity utilisation	% TEU	53%	73%
Load capacity, total all vehicles	tonne	<i>no data</i>	981
Total load carried	tonne	<i>no data</i>	436
Average load capacity utilisation	% tonne	<i>no data</i>	44%
No. of unused TEU positions	TEU positions	36	19
No. of vehicles without any load		12	5
Share of all trucks without any load		31%	14%
No. of vehicles with full load	as TEU	17	22
Share of all trucks carrying full load	as TEU	44%	61%
Total load capacity on vehicles without any load	TEU positions	25	10
Average load, all trucks	TEU	1.0	1.7
Average load, on trucks carrying load	TEU	1.9	2.0
Average load, all trucks	tonne	<i>no data</i>	14
Average load, on trucks carrying load	tonne	<i>no data</i>	27

The data presented in Table 8 above indicates that the load capacity is higher on outgoing trucks which could be an indication of the nature of Stockholm as an import port. It is clear that the load capacity utilisation (LCU_{TEU}) of the truck's leaves room for consolidation and thus reduction of vehicle movements. Especially the observation that totally unloaded trucks make up 30% of incoming and 15% of outgoing traffic is indicating the potential for reducing the traffic.

In order to clarify the situation a data analysis regarding vehicle size and environmental performance was carried out. The data presented in Table 9 indicates that there is no significant difference in load capacity utilisation (LCU_{TEU}) between trucks loading 2 or 3 TEU: s.

Table 9 Truck size and load distribution.

Truck size Load capacity (TEU)	Number of observations	Share	Incoming		Outgoing		
			LCU_{TEU} , trucks with load (TEU)	Number of empty trucks	LCU_{TEU} , trucks with load (TEU)	LCU_{TEU} , trucks with load (tonne)	Number of empty trucks
3	3	8%	67%	1	83%	65%	1
2	32	82%	79%	11	85%	43%	3
1	4	10%	100%	0	100%	92%	1

As seen in Table 9 above the traffic is dominated (>80%) by trucks with a 2 TEU load capacity. One out of three of these trucks arrive to the terminal without any load and 1 out of 10 leaves the terminal empty. The number of observations of 1 and 3 TEU vehicles is too small to analyse any differences when it comes to load capacity utilisation. Looking at the age distribution of the vehicles we can note a deviation from the picture indicated by the hauliers, see discussion with hauliers below. The composition of the fleet is depicted in Table 10.

Table 10 Road traffic to Stockholm container terminal, age distribution.

Vehicle category/generation	No. of observations	share	average age (year)	Average distance to destination (km)	Share of all traffic work (% of vkm)	Share of traffic in the city/DPA (% of vkm)
Euro class 6	17	44%	2.5	52	42%	46%
Euro class 5	12	31%	6.8	86	48%	33%
Euro class 4	2	5%	10.0	11	1%	2%
Euro class 3	7	18%	12.9	26	9%	19%

Although the traffic is dominated by modern vehicles (75% Euro class 5 and 6), old vehicles (average age >10 years) still constitutes one quarter of all vehicles calling to the terminal.

The container terminal operator supplied the project with data on destinations for the outgoing vehicles why an average driving distance per category (i.e. Euro class/vehicle age) could be calculated, see Table 11. It is unsatisfactory from an environmental perspective that (in 2018) some 20% of all traffic work in the densely populated areas surrounding the port terminal is produced by 13 year old vehicles. The connected emission profile of these vehicles yields the emission data for all traffic to the terminal, on average 210 vehicles per day, se result in Table 11.

Table 11. Daily emissions per 24 h to air from road traffic to and from Stockholm container terminal.

Vehicle category/generation	CO ₂		NO _x		PM	
	kg/24H	share	g/24H	share	g/24H	share
Euro class 6	4 496	46%	1.6	4%	27	4%
Euro class 5	3 134	32%	18.4	46%	203	30%
Euro class 4	220	2%	1.6	4%	12	2%
Euro class 3	1 934	20%	18.4	46%	431	64%
Total	9 784		40 174		673	

It is clear that the old trucks (Euro class 3) is a main contributor to the total emissions of particles (PM) and Nitrogen oxides (NO_x), 64% and 46%, while only making up 20% of the traffic work. In comparison one can see that the 46% of the traffic work produced by Euro class 6 vehicles only causes 4% of the NO_x and PM emissions. The benefit of phasing out the oldest vehicles by replacement with new Euro class 6 vehicles/engines is evident.

The external cost related to these emissions is further assessed by applying the standard ASEK-values as presented in Trafikverket (2018). The resulting external cost estimates are presented in Table 12 below.

Table 12 External costs [SEK] due to road traffic thru Densely Populated Areas (DPA) when driving to and from Stockholm Container terminal.

Vehicle category/generation	External Costs while passing DPA, according to ASEK					
	CO ₂	NO _x	PM	Total	All traffic	
	SEK/truck	SEK/truck	SEK/truck	SEK/truck	SEK/day	share
Euro class 6	56	0,7	2,4	59	5 417	29%
Euro class 5	55	12	26	93	6 019	33%
Euro class 4	56	15	22	93	421	2%
Euro class 3	58	20	94	173	6 538	36%
					18 400	

The external cost related to a single truck calling to the terminal is some 60 SEK for a Euro class 6 vehicle and 90 SEK for the Euro class 5 and 4 vehicles and 170 SEK for a Euro class 3 truck. The external societal emission related costs within the city area, for all the truck movements to the Stockholm Container Terminal, is thus in the order of 18 000 SEK per day. It is noteworthy to observe that more than one third (36%) of this cost is caused by the oldest vehicles (> 12 years) while these vehicles produces below one fifth (18%) of the traffic work.

The air pollution related external cost of a truck calling to the port terminal is thus 3 times higher for a Euro class 3 truck than for a modern Euro class 6 truck, this mainly due to the larger emissions of particles. It is noteworthy that climate related impacts constitute over 90% of the external costs related to the most modern trucks. These numbers indicate that the most urgent changes in order to mitigate air pollution related societal costs are i) removing the oldest vehicles and ii) phase out the fossil fuels from the remaining traffic.

3.1.4 Port of Gothenburg

Case description and methodology

The truck traffic to and from the Gothenburg Port Container terminal (Skandia Harbour) has previously been investigated (see further Bäckström and Waidringer, 2015) in terms of i) vehicle route selection, ii) nationality of the drivers and iii) age composition of the vehicle fleet. Unpublished material from this investigation has been made available to this project by the Port of Gothenburg.

There are five major access routes to and from Gothenburg : a.- E6N, b.- E45, c.- E20, d.- Rv40, e.- E6S and four different routes for passing through the city area when approaching the port: 1. North route, 2. Lundby passage (city centre), 3. South river bank (city centre) and 4. South route, see map in Figure 5 below. The investigation made in 2015 revealed the following split of the traffic volumes between the different routes through the city: 1) 9%, 2) 55%, 3) 16% and 4) 20%. From the perspective of city development and road congestion route 2), the Lundby Passage and subsequent connection to E6N/S, Rv 40 and E20 (indicated in red in figure below), is the most problematic road stretch. Relocation of the traffic flow from Lundbyleden to the north and south routes would relieve the central road network and hence reduce the local air quality and noise issues related to the heavy freight traffic. This would contribute positively to the city development plans for the south shore of Hisingen and reduce the traffic congestion issues through and around the Tingstads passage. The major impact on local air quality, from the investigated truck traffic is caused by the trucks choosing route 2 and 3, this since they pass through the city down-town area.

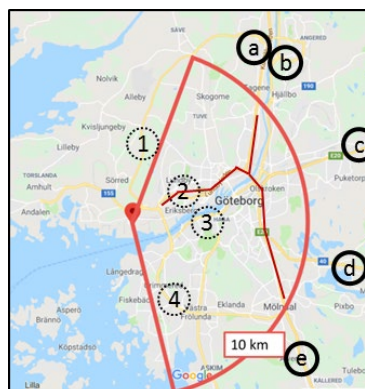


Figure 5 Traffic routes to and from the Port of Gothenburg APMT - container terminal (marked as red dot).

The 2015 investigation of the road traffic did not make any record of the vehicle load capacity (LCTEU) nor the vehicle load capacity utilisation (LCUTEU), i.e. how many TEUs carried by each vehicle. A new observation study was therefore conducted within this project in September 2018. The traffic into the APM Terminal at the Skandia Harbour was at the time of the observation split between two entrance gates. Gate 4 is the main entrance for transports of loaded containers while gate 3 is the entrance to the empty container stack, see Figure 6. A share of the trucks calling to the port makes a stop at both gates, thus empty trucks frequently leaves one of the gates (after dropping off units) just for a short trip over to the other gate in order to load up. The vehicle count was therefore carried out by simultaneously observing ingoing and outgoing traffic at both gates, this in order to identify the trips directly between the terminals. These trips were eliminated since no passage through the city was done on these trips. There was no information available regarding the origin of the vehicles, hence no clear base existed for separating trucks engaged in local or regional/national /international traffic. An attempt to define the arriving trucks was made by sorting out the trucks which made two (or more) separate calls to the port during the 2.5 hours observation period. These vehicles are classified as local, the rest 'long-distance'. Due to the limited length of the observation period will a number of trucks engaged in local traffic be listed as long-distance, this since if they only made one call to the port during the short observation period. The port terminal was unable to supply the investigation with listings of vehicle arrivals and loads. The following information was recorded for each vehicle passage: time, direction, registration number, load capacity of the vehicle combination (as number of TEU positions), number of and type of containers carried (i.e. 20- or 40-foot units). We had no access to information of the load or gross weight of the containers why we only recorded the vehicle load capacity as number of available TEU-positions utilised. The presented values could therefore be underestimating the actual load capacity utilisation since the maximum possible weight of a fully loaded 20-foot container is close to the pay load weight capacity of the 2 TEU vehicles. Thus, a vehicle carrying one such a container would erroneously be noted as having 50% LCU by TEU positions while actually having a 100% LCU by weight. The observations in Ports of Stockholm indicated that approximately 5% of all vehicles had a LCU(w) which was larger than LCU(TEU-position). This error is not further investigated in the case Port of Gothenburg due to lack of data records and this factor is neglected in the analysis.

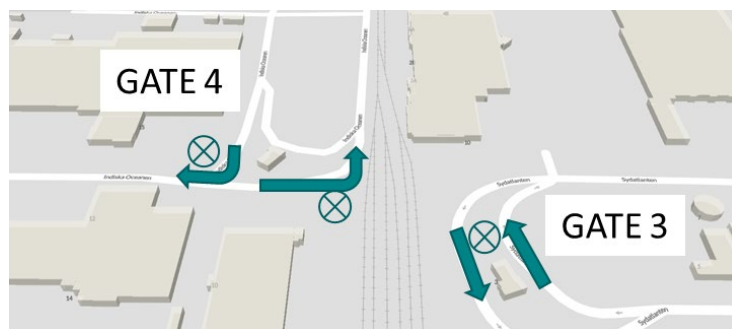


Figure 6 Traffic direction and positions for observing incoming and outgoing traffic.

The analysis of the observed traffic yielded the following results concerning capacity utilisation, vehicle age and environmental performance.

Vehicle Load Capacity and Load capacity utilisation

The observation period lasted for 2,5 hours during which 362 observations were made. After eliminating observations of vehicles entering both gates during one call, a total of 150 unique truck calls were registered. These arrivals and departures thus related to the use of the public road network trough and around the city. The route study made in 2015 showed that 92% of the trucks used the

access routes listed above, only 8% had origin or destination west of the port (Torslanda, Arendal etc.). Of these 71 were registered as local transports (i.e. trucks making more than 1 call during the 2.5-hour long observation period) and 79 as long-distance. The vehicle load capacity and Load Capacity Utilisation for this traffic is presented in Table 13.

Table 13 Load capacity and LCU of incoming and outgoing trucks.

		All vehicles		Local		Long-distance	
Observations	trucks	150		71		79	
Total TEU load capacity	TEU	337		166		171	
		Incoming	Outgoing	Incoming	Outgoing	Incoming	Outgoing
Total LCU	%	56%	67%	56%	58%	54%	75%

Data in Table 13 indicate that the local traffic is using a fleet consisting of larger vehicles than the long-distance traffic. This somewhat unexpected observation could however be due to a mix of local and long-distance trucks in the long-distance category. The 4 TEU trucks are operating on a special limited approval, however, trucks with three TEU capacity is allowed on the main Swedish road network why this combination is the most rational to use in long hauls. The large share of 2 TEU trucks could also indicate a large share of international transports or transports made by foreign trucks under the European cabotage rules.

Table 14 Fleet composition by load capacity.

	All vehicles	Local	Long-distance
4 TEU	2%	3%	0%
3 TEU	21%	28%	15%
2 TEU	77%	69%	85%
1 TEU	0%	0%	0%

The load capacity utilisation by TEU position ($LCU_{(TEU)}$) is the same for incoming and outgoing local trucks, 56%. The low average LCU-value is due to a large share (37%) of empty trucks in the local traffic. The long-distance traffic shows a similar low LCU on the incoming trucks while the outgoing traffic shows a significantly higher value, 75%. Again, this is found to be due to the share of vehicles leaving the port with no load, which in this case is lower, 18%, see Table 15.

Table 15 Load capacity utilisation, detailed.

	Total		Local		Long-distance		
	incoming	outgoing	incoming	outgoing	incoming	outgoing	
Vehicles with, share of total							
no load	37%	25%	35%	37%	38%	18%	
part load	15%	14%	15%	12%	14%	16%	
full load	49%	60%	49%	51%	48%	66%	
Load capacity utilisation on vehicles carrying load							
Total	87%	91%	87%	91%	88%	90%	
4 TEU	100%	100%	100%	100%	-	-	
3 TEU	78%	88%	74%	83%	83%	90%	
2 TEU	91%	91%	94%	93%	89%	89%	

The LCU of the trucks carrying load is in all cases but two around 90%. The local traffic with 4TEU trucks shows a 100% load capacity in both directions, probably due to the nature of the logistic set up served by these vehicles (probably shuttles in a high-volume set-up). The other deviation is found in 3 TEU vehicles in local traffic which shows a lower LCU. This could be an indication of the difficulties filling up a larger truck due to sharp time conditions found in many logistical set ups. There is thus an unused potential to reduce the traffic by reducing the number of empty trucks.

Another way of analysing the situation is by observing that for the trucks calling to the Port of Gothenburg is the average Load Capacity as TEU-positions (LCTEU) 2.25 TEU. The largest LCTEU for standard trucks is 3 TEU why there is a potential for reducing the number of trucks passing through the city by transporting the same amount of cargo on larger trucks, i.e. eliminating the common 2 TEU capacity tractor and semi-trailer combination. The other observation is that the average load is 1.25 TEU on incoming trucks and 1.5 TEU on outgoing trucks (including empty trucks). The potential for better utilisation of available load capacity is thus high and would also lead to reduced traffic volumes.

The combined potential for reducing number of trucks needed for carrying present container volumes to and from the port terminal is thus significant. Some theoretical potentials are calculated and presented in Table 16 below. It is important to point out that several of the reasons why these potentials aren't realised today lies outside the influence of the haulier, e.g. stringent pick-up and delivery time windows, terminal opening hours, locations of destinations, queuing and waiting times (at terminals, in congested traffic and at destinations) and limits set by drivers' schedules.

The potentials analysed is the switch over to larger vehicles which in improved logistical set-ups could carry more TEU per vehicle. The resulting theoretical potentials are presented in Table 16.

Table 16 Traffic reduction potential with efficiency measures.

Measure	Reduction of traffic volumes
No empty trucks	
when today's empty trucks have a LCU_{TEU} as today's average loaded trucks	30%
Only large trucks	
when all trucks can carry 3 TEU <u>and</u> have a LCU_{TEU} as today's average loaded trucks	50%
Consolidated transport	
when all trucks can and do carry (i.e. $LCU_{TEU} = 100\%$)...	
3 TEU	60%
4 TEU	70%
6 TEU	80%

The results presented in Table 16 indicate significant theoretical potentials for reductions of heavy truck traffic through the city of Gothenburg. The large number of inhibiting factors (see text above) should be further investigated in order to assess the realistic reduction potential. It is of special interest to find out if the stated inflexibility also concerns new logistic set ups or if they are better when it comes to fill up large vehicles. This issue is further commented in the discussion below.

The last three potentials are presented as illustration of the outcome of a system where larger vehicles are used to transport the containers through the city. A pre-study for implementation of such a system is presented in Bäckström and Waidringer, 2015. The system is described in the section "Suggestions for further work" below.

Environmental performance and traffic volumes

The total traffic work produced by the heavy vehicles during their passage of the city area is estimated as follows:

The average driving distance within the city area is estimated to zero for the north and south access routes (1 and 4) and 12 km for the central routes (2 and 3). The traffic enquiry made in 2015 showed that 70% of the trucks used route 2 and 3 on their way to and from the port.

The traffic intensity to the terminal shows two peaks during the day, first in the morning and then during mid-afternoon. The field observations in this study were made during the morning rush hours why the traffic intensity can't be extrapolated to the entire day. The total daily traffic volumes are therefore estimated by assuming average traffic intensity during the day equivalent to two thirds of the peak intensity.

The total traffic work is related to both congestion and local air quality issues. The traffic work is therefore presented divided by both vehicle euro-class (related to air pollution) and vehicle size (congestion).

The numbers presented for the emissions and related external societal costs makes it evident that old trucks and trucks operating on fossil fuel (diesel) is causing the largest impact. The external cost related to the city-passage of 1 TEU with a Euro class 6 truck is 1/3 of the cost with a Euro class 3 or Euro class 2 truck. The Euro class 2 and 3 trucks produces 10% of all traffic movements while causing 24% of the external costs related to air pollution and climate effects, see Table 17. A majority of the vehicles are modern, Euro class 5 or 6 engines make up 84% of the truck fleet.

Table 17 Daily traffic work, emissions and external costs (air pollution) related to vehicle Euro class.

	Traffic work / 24H	Emissions per 24H			External costs		
		CO ₂ kg/24H, share)	NO _x (g/24H)	PM (g/24H)	Total (SEK/24H)	SEK per vehicle	SEK per TEU
Euro class 6	6 810 (64%)	6 689 (65%)	2 449 (9%)	40 (9%)	8 060 (49%)	28	23
Euro class 5	2 150 (20%)	2 086 (20%)	12 273 (43%)	135 (31%)	4 006 (24%)	45	36
Euro class 4	573 (5%)	559 (5%)	4 218 (15%)	31 (7%)	1 067 (6%)	45	36
Euro class 3	1 004 (9%)	1 030 (10%)	9 811 (34%)	229 (53%)	3 481 (21%)	83	66
Euro class 2	143 (1%)	142 (1%)	1 743 (6%)	33 (8%)	507 (3%)	85	68
Total	10 680	10 364	28 751	436	16 614		

The other decisive aspect on environmental performance is the size and load capacity of the trucks. The analysis shows that although the 3 TEU trucks are more efficient does the 2 TEU dominate the traffic, see Table 18.

Table 18 Traffic work and external costs (air pollution) related to vehicle load capacity.

	Traffic work		Transport work	External costs		
TEU capacity	vkm/24H (share)	vkm/TEU	Share of TEUs transported	Total (SEK)	SEK per vehicle	SEK per TEU
4	215 (2%)	9	4%	441 (2%)	49	18
3	2 222 (21%)	15	26%	4 065 (23%)	44	28
2	8 315 (77%)	21	70%	13 216 (75%)	38	34

Note that the data presented for 3 TEU trucks above is measurement data which includes the lower LCU of the 3 TEU vehicles (75%) as compared to the 2 TEU trucks (95%). The large potential for the often fully loaded 4 TEU vehicles is illustrated by an external cost of 18 SEK/TEU per passage, half of the 34 related to the 2 TEU vehicles.

The environmental performance of the road traffic is governed by the combination of engine and fuel type. The type of fuel could not be assessed by the observations made why the fuel type stated in the vehicle registry was assumed to be used. The records of the vehicle number plates made it possible to obtain data regarding each individual vehicle. The following data was compiled for the vehicle collective calling to the terminal during the observation period, see Table 19.

Table 19 Road traffic to Port of Gothenburg APMT container terminal, vehicle data.

	Share	Average age	External cost SEK/terminal call
Euro class 6	63%	3	30
Euro class 5	20%	7	46
Euro class 4	5%	11	46
Euro class 3	9%	13	86
Euro class 2	1%	17	88

The average age of all trucks is 5.2 years and the average Euro class is 'Euro 5,3'. Again, the high societal cost of operating less than Euro 4 engines is evident. The numbers presented above is however based on emission data from new vehicles and the low cost for the Euro 6 vehicles is related to the use of advanced pollution abatement equipment. The correct operation of this equipment is essential for maintaining the low emissions why there is an increasing risk for malfunction with increasing vehicle age. This aspect must be taken into care when assessing future emission data for the truck traffic and systems for control measurements could be considered for random tests of vehicles claiming low emissions, e.g. in connection to a fee system.

The observations above all indicate the positive potential with moving from present operations and vehicle fleet to a system where larger and modern vehicles carry out all transports through the city. Along with the reduction of the number of heavy trucks on the roads will the external costs per TEU be cut by two thirds, from 30 SEK/TEU to 11 SEK/TEU.

Table 20 Potentials for reduction of external costs

External costs reduction potential	SEK/TEU
Today average	30
All vehicles Euro class 6 and 3 TEU	11
All vehicles Euro class 6 and 4 TEU	10
All vehicles Euro class 6 and 6 TEU	7

When operating Euro class 6 engines will the larger share of the external cost originates from the emission of fossil CO₂ originating from the fuel. By increasing the vehicle size (to 4 or 6 TEU) one will also increase the fuel consumption. The relative difference in fuel efficiency decreases with increased vehicle size why the relative improvement in external costs decreases. The use of 4 or 6 TEU vehicles will thus not have an as large impact on emissions to air, indicated in Table 20 above.

The benefits from reduced number of truck movements in the road infrastructure (reducing the congestion) is not included in the external cost benefits reported here.

Conclusions regarding Port of Gothenburg

This investigation has shown that the road-based container transports to and from the Port of Gothenburg operates under non-optimal conditions. A large number of trucks arrives to or leaves the terminal with no load, the majority of the trucks only loads 2 TEUs (while 3 TEU trucks are allowed) and 11% of the trucks are using outdated high polluting engines (Euro class 2 or 3). This makes the truck traffic, through the densely populated areas of Gothenburg, to cause unnecessary disturbances in the form of congestion, noise and air pollution.

3.1.5 Possible regulation structures

In this chapter, design of the possible landside regulation is based on an entrance fee to the port area. The implementation of regulating gate fees at port terminals will from a cargo owner's perspective be perceived as a cost increase. If a fee is not implemented in all ports at the same time, there is a risk for selection of another port or transport solutions if the cost increases above a threshold level. This threshold will vary between each cargo flow and the impacts on cargo movements must be investigated in detail on a case by case base before implementation.

From the sustainability perspective the rationale behind a gate fee will be to induce changes in how the cargo is brought to and from the terminal. The fee can address several issues such as:

- Emissions of climate gases, e.g. fossil CO₂, CH₄ and N₂O
- Emissions of NO_x, HC, PM causing local air pollution
- Congestion in urban road network
- Barrier effects and limitations for exploitations
- Noise disturbances during day and night time
- Road accidents
- Safety – dangerous/hazardous goods

The traffic related aspects are of special concern for a surrounding city area hosting a densely populated area (DPA). Road traffic through the DPA will impact air quality, noise levels, congestion, traffic accidents and safety issues while rail passage (in the case of electrified main lines) mostly contributes to noise, barriers and safety issues.

From a city perspective the air quality, barrier effects and safety issues are in focus why road traffic naturally comes more in focus when local sustainability problems are to be mitigated. It is however equally important to keep in mind that transfer over to a rail solution won't remove all conflicting aspects regarding the traffic to and from the port terminals. A total elimination of the impact from the hinterland cargo traffic on the city and its inhabitants can only be achieved by relocating either the port or the city. So, the ambition with a fee system must be to achieve realistic improvements of the transport systems without jeopardizing the operations of the port, neither the development of the city nor the wellbeing of its inhabitants and businesses.

The introduction of any fee structure will increase further the (already existing) rationale to use trucks with high load capacity and to make sure that these vehicles are carrying as much load as possible. This would reduce the number of truck movements through the city area. Apart from this effect, different structures of the fee can also address other aspects of the traffic, for example distribute the arrival time of the trucks to the port gate to reduce congestion.

Theoretic potentials

The investigation has shown large potentials for reducing the number of truck movements needed to transport present container volumes to and from the port terminals. The main short-term potential is found in logistics re-organisation making it possible to better utilise the present vehicle fleet, i.e. increase the vehicle load capacity utilisation by making sure that the trucks are full. For the Port of Gothenburg, a theoretical potential of 30% reduction of trucks traffic were indicated. The second short term action would be to use vehicles with larger load capacity. Today is the traffic dominated by the tractor+semi-trailer combination (with 2 TEU load capacity). If this vehicle is replaced by the truck+dolly+semi-trailer combination (with 3 TEU load capacity) the number of trucks passing through the city could be reduced by 50%, see Table 21 below.

Table 21 Calculated maximum potentials for traffic reductions through Gothenburg City.

Measure	Reduction of traffic volumes
When todays empty trucks have a LCU_{TEU} as todays average loaded trucks	30%
When all trucks can carry 3 TEU <u>and</u> have a LCU_{TEU} as todays average loaded trucks	50%
When all trucks can and does carry (i.e. $LCU_{TEU} = 100\%$)	
3 TEU	60%
4 TEU	70%
6 TEU	80%

The purpose of a port gate fee would be to stimulate all actors in the transport chain (i.e. shippers, consignees, integrators, hauliers, port terminal and city- and road authorities) to make changes that facilitates the suggested mitigation actions. The theoretical potential only serves as an indication while the realistic potential must be based on a broad analysis covering several aspects concerning each stakeholder. An attempt to make such a judgement is presented in next section.

Estimations of real potentials

To estimate the potential or the gate fee an expert workshop and interviews with road haulers have been carried out in the project.

Expert workshop

In order to capturing industry representatives' views on the design and level of truck traffic charges to port terminals, a workshop was carried out at the third reference group meeting February 1, 2018. The purpose of the workshop was to structure the question in a structured way and then capture all participants' assessments to make a balanced conclusion regarding the likely degree of influence at the given level of port entry charges. Background material and preliminary design of two gate fees were provided to the expert groups before the meeting with details on the suggested incentive scheme, see Suggestion 1 and Suggestion 2 below. The workshop participants were divided into four smaller groups at the meeting, where two groups discussed the proposals for truck charges.

Suggestion 1: Congestion gate fees for trucks

The design: This action option involves the introduction of an entry fee charged by all vehicles at the port to the container port terminal according to the following criteria:

- All trucks passing through the gate to the port during peak hours pay a fee of SEK 200 per entry.
- Peak hours are defined as times when there is a high strain on the road network in the surrounding urban area or in high demand for entry into the port. The following times are chargeable: weekdays from 06:30 to 9:00 and from 14:00 to 18:00. The fee is similar to the congestion tax in Stockholm and Gothenburg, but with advanced start time in the afternoon from 2:00 pm to tackle queue issues that usually arise at the port gate after this time.
- The fee is introduced in all Swedish ports with container traffic.
- The size of the fee is the same for all vehicles regardless of age, environmental class, size or load capacity and degree of filling.

Purpose: The purpose is to reduce congestion and increase accessibility by reducing the number of trucks passages through the urban area and the port during rush hours.

Who charges the fee: The terminal operator.

Who pays the fee: The fee is paid by the driver directly at the port gate, either in cash or by card (similar to existing system for infrastructure fees in Europe, i.e. bridge and road charges).

Who manages / takes care of the money: The money is paid into a fund from which the money is distributed to environmental improvement measures, such as for investment in noise barriers, building rail infrastructure, alternative fuels / energy carriers, power stations, innovation projects to reduce truck traffic problems through the city, etc. The money is managed by a national foundation that is separated from the municipality and the port. The port authority or terminal operator do not possess the money. The money is supposed to be used for effective measures to reduce negative impacts from freight traffic through the city, for example reduced noise, reduced congestion, reduced contribution to air pollution, reduced climate impacts, increased road safety, reduced dependence on imported energy carriers.

Result: The task of the group at the workshop was to estimate the percentage of trucks that would change their arrival time if a congestion gate fee was introduced in container terminals. The result of the discussion showed unequivocally that the proposed fee of SEK 200 per truck passage was considered too small to have a larger impact. The overall assessment resulted in that the group agreed on a median value of 15% of the trucks would change today's plans to avoid the fee, with a min-value of 5% and max-value 30%. Changes in transport planning were stated to be starting at a fee of SEK 200, and higher fees would probably lead to a change, no exact fee level could be specified for a charge with good governance. It is discussed that cargo with more flexible logistic set ups will introduce changes for increased efficiency at lower fees. The consignees' time requirements were stated by several participants as the main reason for the difficulty of changing the arrival time to the port terminal. Also driving times and drivers' work schedules were considered to be limitations. The group's analysis thus confirmed the image presented by the hauliers regarding the minimum level of fees, see "Discussion with hauliers" below in this chapter.

Suggestion 2: Environmental fees for trucks

The design: This option implies the introduction of a port gate entry fee, but with a differentiation depending on environmental performance of the truck's engine:

- Trucks that enter through the gate to the port have to pay a fee of 200 SEK/entry. The fee is charged irrespective of the size of the vehicle, the amount of load carried or time for entering.
- Diesel-powered trucks with engines of Euro class 6 will be given a discount of 50% and pays a fee of 100 SEK/entry.
- Electric/hybrid vehicles and gas vehicles (CNG/LNG/Dual Fuel) are fully exempted from charges (100% rebates).
- The fee is introduced in all Swedish ports with container- and RoRo traffic.

Purpose: The purpose is to achieve environmental improvement measures by favouring trucks with high environmental performance, thereby lowering local emissions of pollutants such as nitrogen oxides (NO_x), Hydro carbons (HC) and particles (PM).

Who collects charges: The terminal operator.

Who pays the fee: The fee is paid by the driver directly at the port gate, either in cash or by card (similar to existing system for infrastructure fees in Europe, i.e. bridge and road charges).

Who manages / takes care of the money: The money is paid into a fund from which the money is distributed to environmental improvement measures, such as for investment in noise barriers, building rail infrastructure, alternative fuels / energy carriers, power stations, innovation projects to reduce truck traffic problems through the city, etc. The money is managed by a national foundation that is separated from the municipality and the port. The port authority or terminal operator do not possess the money. The money is supposed to be used for effective measures to reduce negative impacts from freight traffic through the city, for example reduced noise, reduced congestion, reduced contribution to air pollution, reduced climate impacts, increased road safety, reduced dependence on imported energy carriers.

Results: The result of the group's work showed unequivocally that the proposed fee of SEK 200 per truck passage was considered to be too small to have any significant impact. The group's overall assessment was that around 3% of the trucks would change today's operations in order to avoid, or decrease, the fee. As a result of the smaller impact potential, it was stated that the fleet which operates on the port terminal already today to a large extent is 'modern' and thus already fulfils the Euro class 6 requirements⁶.

Discussion with hauliers

During the project we have attempted to involve hauliers as a reporting provider and to get their views on issues about the charges and the effects of different levels. It has been difficult to get hauliers to engage in reference group meetings, but we have conducted a few interviews with companies with extensive lorry traffic to port terminals. These interviews have been done by phone and we have talked with people involved in traffic planning and price calculations.

For one of the larger hauliers in Gothenburg it was stated that their trucks are calling to Skandia Harbour about 150-200 time a day and that transport missions evenly distribute between long-distance (national and regional) and local transport. A long-distance transport typically means between 150 and 500 km. Cargo to and from places further away tend to use other ports or is lifted onto rail transport. Local transports are usually less than 30 km one way. As far as utilization of truck load capacity is concerned, the haulier indicated that this is very high for this type of transport, 90%

⁶ The observations in this report to some extent confirmed this statement (83% Euro class 5 or 6 in Gothenburg, 75% in Stockholm). The remaining Euro class 2 and Euro class 3 vehicles did however contribute significantly to the total external costs due to high pollution levels.

values were stated with the motivation that the price squeeze is so hard that “you cannot drive the traffic with less than full trucks”.

As for the price model, the customer can either pay for the entire truck and the transport is then controlled by the customer regarding times of pick up and drop of the goods. The alternative is to buy a slot/position on a car carrying other goods as well. This transport will be cheaper, but the customer will have less control regarding the time when the goods are to be picked up and delivered. Waiting time for the truck is charged if the goods cannot be loaded or unloaded at the specified time. This compensation is heavily discounted according to the hauliers. Normally, approximately 500 SEK / hour is charged even though the fixed production cost (for the truck and driver) is usually more than double that price. Thus, waiting times and longer travel times due to queues are a major problem for the hauliers.

When planning the transports, the time windows for pickup and delivery are putting strict demands. This leads to a limitation in the traffic planners ability to create full loads on every truck going to and from the port terminal. Apart from customer demands uncertainties regarding travel times during congestion periods, in combination with varying waiting times at the port terminal, will make it further complicated to plan routes with high vehicle load capacity utilisation.

In the conversation it was clear that port gate entry charges in the order of 200-300 kronor that have been discussed and analysed in this project, cannot be expected to affect the way truck traffic is planned or implemented. The above-mentioned time requirements are far too strict and the extra cost for the transport will in most cases be accepted by the customer instead of changing the production system into which the container transport connects. In the case of long journeys, where rail transport is an option, loading charges for the truck would probably be required to exceed 400-600 SEK before such relocations were to be considered.

In summary, the hauliers estimate that the fee levels that the project detailed study (about 200 SEK / vehicle) would not at all affect how today's trucking is being carried out. The fee should the haulier attempt to inflict on the customer, and it is not estimated that the proposed fee rate would motivate today's customers to change their time requirements to avoid the extra cost. Customers' costs of changing timetables for freight transport (which are integrated in internal production / working hours) are expected to by far exceed the proposed entry fee.

3.1.6 Summary and discussion

The purpose of this chapter was to assess the potential to use port gate access fees to reduce the number of trucks passing through the densely populated city area (on their way to and from port terminals). The logic behind realising this by a port gate entry fee is based on the existence of flexibility regarding when and how the transport is produced. The main theoretical potential was shown to be found in different truck planning and routing, this in order to i) make use of trucks with larger load capacity and ii) to fill up each vehicle better. The discussions with hauliers gave at hand that port entry fees at the suggested levels (200 SEK) would have no or very little impact on present traffic volumes. The increased transport cost that customers would experience would in general not motivate the higher costs for alternations in the production plans. Whether this statement is valid or not has not been challenged in this study, however given the relatively low prices for cargo transports it is believed to hold true for a majority of the senders and receivers of containerised goods. A gate fee that induce changes in the logistics planning must thus be much higher, and probably be ramped up during a longer time period to give time for necessary changes in the logistic

puzzle. It is likely that the total cargo volumes in port will be affected negatively by high fees since cargo less dependent of the specific advantages in the port could find other, cheaper, alternatives.

This investigation has shown that the road-based container transports to and from the Ports of Stockholm and Port of Gothenburg operates under non-optimal conditions. A large number of trucks arrives to or leaves the terminal with no load, the majority of the trucks only loads 2 TEUs (while 3 TEU trucks are allowed) and 10-25% of the trucks are using outdated high polluting engines (Euro class 2 or 3). This makes the truck traffic, through the densely populated areas of the port cities, to cause unnecessary disturbances in the form of congestion, noise and air pollution.

This situation is unsatisfactory to the concerned cities why different mitigation activities are being initiated. The Ports of Stockholm is in the process of moving the container port terminal from its central location to a remote location south of the city. However, the traffic related issues emerging in the new location could possibly be of equal concern, especially considering that new traffic is introduced on a number of roads. The city of Gothenburg has commissioned the Port of Gothenburg to engage in mitigating actions in order to reduce the problem, especially in connection to the planned down town urban development projects. A short-term solution could be to ban the 10% of today's trucks operating with Euro class 3 and 2 engines from ports with no or small negative effect. The port could for example adopt the city rules banning older trucks from entering the area. This regulation would only allow Euro class 5 and 6 trucks from 2019 and onwards and from 2022 only Euro class 6 trucks. This rule could be motivated by the factor three higher societal external costs connected to air pollution from older vehicles.

In this study were the potentials for improving the traffic by introducing regulatory entrance fees assessed. By applying a fee when a truck enters the gate to the port, improvements could be realised. Different fee structures could address the problems with small, empty and polluting trucks by motivating the actors in the logistic chain to make it possible to more efficiently (loading more cargo) use available larger vehicle combinations powered by modern and less polluting engines.

The theoretical traffic reduction potential, by using larger and better utilised trucks, was found to be between 30-50 %. This means that almost every second truck passing through the city on its way to and from the port terminal could be eliminated by better use of available resources. The reduction in noise, congestion and air pollution would be in parity to these numbers.

However, the suggested fee structures were by expert groups and hauliers assessed not to be very effective, mostly based on the observation that external transports is a relatively small cost in comparison with costs and risks related to reorganising logistics operations. The concept of a port gate fee as outlined in this project is therefore, by the hauliers and experts, predicted to have a limited impact on the present ongoing traffic to and from the port. However, the judgements regarding the potentials for port gate fees made by experts and hauliers' need to be challenged by further investigations.

3.2 Environmental analysis of incentives for sea transport

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This chapter presenting a potential reduction of environmental impacts from ships at the use of incentives implemented by ports. The result is quantified and is the result of a selection process of incentive schemes, discussions with experts and emission calculations. This section of the report includes conclusions and results from the detailed evaluation of two suggested but hypothetical incentive schemes. We also briefly describe the methods used when selecting incentive schemes for further evaluation, and for quantifying their likely implementation rates. The final step includes calculations of emission reductions and in large relies on an emission calculation methodology presented in Winnes et al., 2015.

3.2.1 1st step: Selection of incentive schemes

Within the project, a review of the criteria and indexations used to assess ships' environmental performance has been made (Work package 2). Condensed assessments using for example indexations, may provide support for ports that want to give benefits for ships with high environmental performance or punish those with low performance. The review also included a description of how ports use assessment criteria today and examples of how port dues are differentiated with respect to the environment. A gross list of many criteria, indicators and index systems was described in Work package 2 and found in this report in chapter 2.2.3. The work presented in chapter 2.2.4 also describes how a selection of these has been made for further studies.

Method

Five different criteria or assessment bases are studied in detail. In short, these five systems were selected because they are expected to have a significant positive impact on the environment in relation to the effort required by the ports to introduce and operate them. We further consider them to be reasonable grounds for differentiating the infrastructure dues that are claimed for visiting vessels. Discussions of the selected incentives were held in the reference group.

The selection includes:

- **Environmental differentiation of port dues related to measures to reduce NO_x emissions.** This system is similar to the system previously used by the Swedish Maritime Administration to differentiate fairway dues. The system is based on incremental increase of the incentive / discount on the fee. We also propose a higher weighting of emissions reductions on auxiliary engines since emissions from auxiliary engines cause a majority of the emissions in port areas.
- **Environmental differentiation of port charges related to measures to reduce CO₂ emissions.** This system is proposed to use estimates of the ship's CO₂ emissions calculated according to the Clean Shipping Index (CSI) or Environmental Ship Index (ESI) methods. Both CSI and ESI are relatively well-established indexes. Further, they are both used by ports for environmental differentiation. An alternative for CO₂ differentiation, that was discussed, is to relate a discount to the fuel type used.

- **Environmental differentiation of port charges related to measures to reduce particulate (PM) emissions.** This system is proposed to use estimates and values of ships' PM emissions according to the Clean Shipping Index (CSI) method or equivalent index.
- **Discount on port charges for ships connecting to the land-based power grid when at berth.**
- **Discount on the port due for ships that slows down in the fairway channel.** The discount is given to vessels that slow down near the port city.

The discussions ended with the twelve participants evaluating the environmental potential, industrial acceptance and implementation difficulties, of the suggested criteria. The evaluation was made according to a scale from 1 to 4. An average value was then calculated for each incentive, as indicated in Table 6 in Chapter 2.2.4.

The number of people who participated in the evaluation exercise was too small to indicate definite differences in the valuation of incentives. The mean values that were calculated are predominantly between 2 and 3. An exception is the assessment of environmental potential in shore-side electricity use. For this proposal, the average is 3.7, which means that participants see a high environmental potential in using this as a means of control. Other incentives that reach over a value of 3 are environmental potential and industry acceptance to use PM or NO_x emissions as criteria for an environmental differentiation of dues.

If more people had participated in the exercise, small differences between different incentives could have been considered representative of Swedish ports and stakeholders in general. The result of the exercise should primarily be seen as an indication of whether an incentive is feasible and not used for a mutual ranking.

Interpretation and result

Our interpretation of the exercise results is that all incentives are interesting for further analysis. The reference group values the environmental differentiation of port dues related to measures to reduce particulate emissions and NO_x as most interesting for further analysis. Of these two, we choose NO_x environmental differentiation for further studies as there are few technical solutions to reduce particulate emissions from marine engines available on the market. An instrument targeting emission of PM would be depending on on-shore power supply and alternative fuels. It would therefore probably include a relatively long-time frame for shipping companies to meet any requirements. Differentiation based on NO_x emissions allows a higher variety of solutions for the shipowners and we therefore choose this as one of the measures for continued analysis. The second measure chosen for further analysis includes a discount on the port dues for ships that reduce the speed in the fairway channel. This measure received a low average score in the valuation exercise in the reference group. The reasoning behind the selection is, in part, that the reduced speed is an efficient way to reduce CO₂ emissions. This causes the option of CO₂-based environmental differentiation to be partially covered. We also estimate that a program for reduced speed in Swedish waters leads to positive side effects following reduced fuel consumption. The benefits of reduced air pollution may have a high level of social benefit worth evaluating.

The shore-side electricity option has many advantages since emissions from ships at berth are completely removed except for the time required for the connection and disconnection of the electricity connectors. The alternative is not included in further analysis but is part of the proposal on environmental differentiation of port charges depending on quayside NO_x emissions.

3.2.2 2nd step: Expert elicitation exercise

The two alternatives that are evaluated in this exercise are based on the outcomes of the selection process described above and designed in more detail aiming at a high relevance for the case study ports and a scope that is graspable during discussions:

1. **Environmental differentiation of port dues related to measures to reduce NO_x emissions.** The proposed incentive means that a rebate of 0.50 SEK/gross ton is given to vessels whose auxiliary engines emit less than 3g NO_x per kWh. The suggested discount applies to all Swedish ports and to all vessels except RoRo, RoPax and ferry vessels. These are exempted from the analysis since they are already working with NO_x reducing measures to a significantly greater extent than other ship categories. The discount applies regardless of the age of the vessel.
2. **Discount on the port due for ships that slow down in the fairway channel.** The proposed incentive implies a 15% port due reduction for container ships and RoRo/RoPax/Ferries with a maximum speed of 12 knots in a zone 20 nautical miles (NM) in and out of the port. The discount applies to all Swedish ports, and the analysis is valid for 2020. In the analysis, we limit ourselves to the ship type categories container ships and RoRo/RoPax/Ferries, since these are the most high-speed vessels and thereby have the highest potential for reducing emissions. There are many other ship types, e.g. general cargo and dry bulk, or smaller ships, which already operate around 12 knots.

Proposals of the design of the two incentives were presented to the reference group. The proposal's potential for implementation in the industry was then evaluated during an exercise. The reference group is divided into expert groups of approximately five persons in each. The experts are asked to produce a measure of how likely it is that shipping companies act because of the proposed incentives.

Method

The expert group exercise is done according to a well described so-called expert elicitation method. In short, the elicitation requests experts to leave quantitative estimates of phenomena and events. It may be a matter of estimating how many red cars there are in Gothenburg, or how likely it is that shipowners choose to install catalytic cleaning of exhaust gas on their vessels, given specified conditions, to give two examples. The result of the exercise is a probability distribution that shows the expert group's total subjective probabilities. The method we use follows the guidelines for SHELF, which is described in O'Hagan et al., 2006, and Oakley et al., 2010.

Environmental differentiation of port dues related to measures to reduce NO_x emissions.

The expert group is asked to estimate the percentage of total calls to Swedish ports that will be awarded a discount in such a system. They initially specify a "max" and a "min" value for the implementation rate. Thus, defining the probability limits for the share of ship calls that can be assumed to be made by vessels with the installations and/or rebuilds required. An implementation rate beyond "min" and "max" values is considered extremely unlikely. Individual estimates of the most likely scenario are then requested from each participant. All assumptions are motivated in a discussion. Following the initial individual evaluation is a second evaluation made in the group as a whole during discussion. The quantity requested by the expert group is thus the likelihood that a rebate of 0.50 kr/gross ton on the port due, at heavily reduced NO_x emissions from the ship's auxiliary engines, will cause shipping companies to make the necessary investments. The background material provided experts with details on the suggested incentive scheme, approximate costs of different abatement technologies, and information on ship calls to Sweden. This background material is appended to this report as Appendix 3. This material has been translated from Swedish to English for this report.

The participants in the exercise had different experiences related to the question asked. Those who took part were representatives from 'Clean Shipping Index', Swedish Transport Administration, VTI and the Swedish Maritime Administration.

Slow steaming Rebate on port dues for ships in slow speed in the fairway channel

The expert group was asked to give their best estimate on the percentage of total calls in Swedish ports that will be awarded a discount in such a system. The quantity that the exercise is intended to provide is a measure of the likelihood that 1. Container ships and 2. RoRo ships and ferries will reduce their speed to 12 knots in an area within 20 NM from the port to obtain the specified discount. The expert group has a discussion and provides a "max" and a "min" value for the implementation rate for container and RoRo/RoPax/ ferries. Thus, define the limits on how many of the ship calls in the two ship type categories are expected to sail with modified speeds. The degree of implementation beyond "min" and "max" is considered extremely unbelievable. After this, individual estimates on the probability of adherence to the incentive program are requested. The background material that was provided to the participants provided details on the suggested incentive scheme, references to a similar program in Port of Long Beach and described potential cost savings from fuel consumption reduction and port due rebates. This material is appended to this report as Appendix 4. This material has been translated from Swedish to English for this report.

The participants in the exercise had different experiences related to the question asked. Those who took part were Ports of Stockholm, 'Clean Shipping Index', VTI, Gothenburg University and the Swedish Shipowners' Association.

Result from the expert elicitation exercises

Environmental differentiation of port dues related to measures to reduce NO_x-emissions from ships at berth

Minimum and maximum implementation limits were set at 1% and 70% respectively. This means that the expert group considers it extremely unlikely that less than 1% of the calls would be made by ships without NO_x reducing measures if the incentive was to be implemented. Equally unlikely, they consider that the proportion of calls is higher than 70%.

All experts gave individual median values; the value where they estimated it equally likely that the proportion of calls with low-NO_x vessels was lower than the stated value, as it was higher. Further, they were asked to quantify a lower and upper quartile value. By this they divide the potential result into four equally probable ranges. Between the min-value and the lower quartile, between the lower quartile and the median, between the median and the upper quartile, and between the upper quartile and the max-value, it is equally likely (25% probability) that ship calls are made by ships with high performing NO_x abatement on board.

One participant sets the lower and upper quartiles, and median to 9%, 23%, and 15% respectively. The participant assumes that there are already environmentally differentiated fairway dues that have caused certain reactions from ship owners, and further takes as a standpoint an assumption of how shipowners are thinking. A second participant indicated a lower quartile of 5%, an upper quartile at 70%, and median at 25%. The participant thinks the estimate is difficult to make, since the costs for investment of NO_x abatement technology are hard to calculate. A third participant sets a lower quartile at 20%, an upper quartile at 60%, and a median at 20%, and considers him/herself a bit optimistic. A fourth participant indicated lower quartile at 1%, upper quartile at 20%, and median at 7%. The relatively low estimates from this participant is based on that previous measures taken

by the Swedish Maritime Administration has not been enough to cause many shipowners to apply for NO_x discounts below 6g/kWh. The participant mentions that, on the auxiliary engines, it is more difficult to install NO_x reduction technology, but that shore side electricity may be a more attractive option. The participant mentions that the estimates are to a large extent based on a feeling and that only little has happened in response to existing incentives.

In all, the median values were thus stated at 15%, 25%, 20% and 7%. Following discussions and collective analysis of values and probability distributions, the group agreed on a median value of 16% and a log-normal probability distribution. The group considers 16% to be a reasonable value. One participant says that port dues in general are proportionally larger fees than fairway dues and by that may offer stronger incentive. Another participant mentions that this may be yet one incentive aiming at the same cause as many others, which could be a success factor.

The discussion continued to jointly determine quartiles. The group has difficulties to agree on reasonable values. Someone thinks they can lower the upper quartile to 20%, as there is no awareness of how quickly you can make actual changes on auxiliary engines. Another participant thinks the upper quartile should be raised to 30%. In the final pooled distribution, the group agreed to maintain the common median value, but to adjust the lower and upper quartiles to 4.6% and 23%, respectively.

Figure 7a show the individual expert assessment that they showed before the joint discussion. In Figure 7b, the predicted lognormal probability distribution is based on the linearly pooled function of the values in Figure 7a.

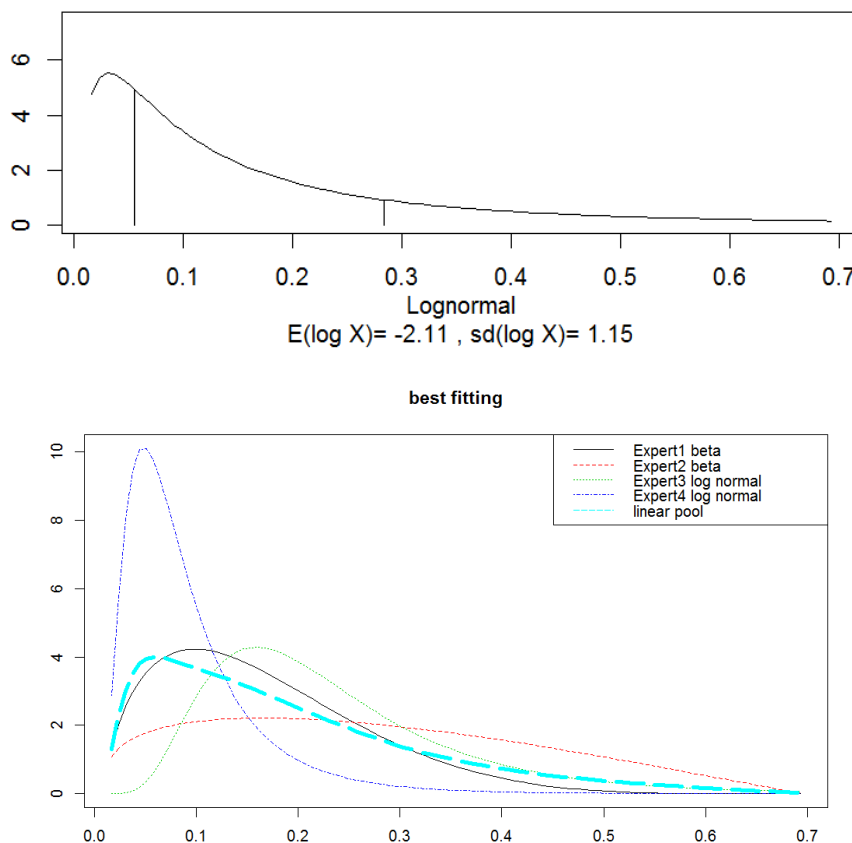


Figure 7a) Experts' individual assessments as well as the linearly pooled distribution. Median: 0.16; Lower quartile: 0.087; Upper quartile: 0.27; 7b) The log-normal probability distribution by the group's common agreement. Median: 0.16; Lower quartile: 0.046; Upper quartile: 0.23; mean: 0.12; standard deviation: 3.2.

Rebate on port dues for ships in slow speed in the fairway channel

General input from the expert group during the exercise comprise concern the potential trade-offs between environmental impact categories. The group reasons that if speed is low this is beneficial from a climate gas point of view but potentially bad from an air pollution perspective. Another comment concerns the differences between ports. In the archipelago outside Stockholm the speed never reaches 20 knots.

Container

Minimum and maximum implementation limits were set at 10% and 80% respectively. This means that the expert group considers it extremely unlikely that less than 10% of the calls would be made by container ships that do not slow speed if the incentive was to be implemented. Equally unlikely, they consider that the proportion of calls is higher than 80%.

All experts were asked to give their individual estimates on median values, and their own estimates on lower and upper quartiles. This divides the potential result into four equally probable ranges. Between the min-value and the lower quartile, between the lower quartile and the median, between the median and the upper quartile, and between the upper quartile and the max-value, it is equally likely (25% probability) that calls are made by ships in slow steaming.

The five experts' values for lower quartile, median, and upper quartile, including the experts' own comments were:

- 20%, 60%, and 80%, the shape of the curve does not agree with what the expert had in mind. The expert wants to change the median value to 50%. The expert mentions a discussion with a ship operator who said that of course it is interesting with rebate suggestions and considers it unlikely that no-one would be attracted by the suggested incentive.
- 12.5%, 15%, and 17.5%, the expert questions why this is not done today. The cost reductions from reduced fuel costs are significantly higher than the suggested rebate in port due (the communicated example shows that 80 000 SEK can be saved for a big container ship and the suggested difference in port due would be around 15000 SEK).
- 40%, 70%, and 75%. The expert expresses interest/uncertainty of how far from a port a ship slows down prior to a call. He/she mentions that the difference in time is small and it is therefore likely that the participation would be high.
- 20%, 30%, and 50%. The expert is concerned that many ships already sail in speeds down to 12 knots, although possibly not container ships. The expert excludes the largest ships in the category since they most likely have beneficial deals with the port on port dues. They also have high costs for delays because of the large volumes of goods and crew on board. Feeders on the other hand keep a speed close to 12 knots (15-16) and could possibly be attracted by the incentive. The expert continues that feeders are rather slow today and that with just a few ships changing operational routines (timetables/speed) it could probably be rather effortless to reach 10% of the calls with the incentives.
- 7%, 15%, and 20%. The expert wants to keep his/her lower quartile value despite that it is lower than the agreed min-value. The expert expresses that different ship types have different design speeds, and that the limit of 12 knots might have a large effect. Many ship owners work with several efficiency measures already, and it is therefore doubtful that slow steaming incentives would make a difference. The expert is concerned about the prerequisite that the same incentive should apply in all ports. This contributes to the low values stated by the expert. An incentive including slow steaming is better applied on longer distances outside the port area according to the expert.

In a discussion over the resulting pooled probability function the group states that there are two peaks on the curve; one at low probabilities and one close to the maximum value. To a large extent the peak close to the max value is due to the probabilities given by the expert with a median value and upper quartile at 70% and 75% respectively. This expert agrees to compromise with the group in order to reduce the upper peak. The resulting agreed median value is at 34% in a beta shaped distribution, see Figure 8.

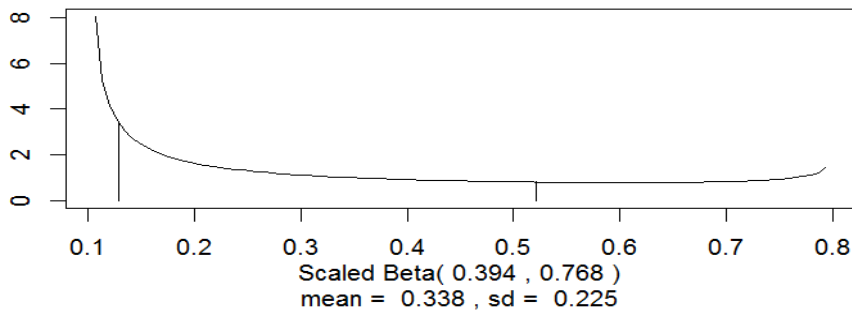


Figure 8 Agreed probability distribution, case container ships.

A curve with two nodes like the one in this exercise is an indication that the expert group does not have a unified idea on the implementation rate following the discussed measure. Many uncertainties in the results are discussed and two of the experts would like to complement results in discussions with ship owners if the results should be used in other contexts than this project.

RoRo/RoPax/Ferry

The minimum and maximum values for the plausible range of results are agreed to be 0% and 50% respectively. The expert group thus considers it extremely unlikely that more than 50% of the calls would be made by RoRo/RoPax/Ferry ships that do not slow speed if the incentive was to be implemented. The minimum is set to 0%, indicating that the measure might be without effect.

As described previously, all experts were asked to give their individual estimates on median values, and their own estimates on lower and upper quartiles that divides the potential result into four equally probable ranges.

The five experts' values for lower quartile, median, and upper quartile, including the experts' own comments were:

- 10%, 15%, and 20%. This expert believes it to be more likely that RoRo ships can have adjusted speeds according to the suggested scheme than RoPax ships, and that the implementation rate therefore will be higher among RoRo ships.
- 7.5%, 10%, and 12.5%
- 10%, 15%, and 25%. This expert believes that it is less likely that these ship types will adjust speed according to the suggested incentive than container ships, since the RoRo/Ro/Pax/Ferry category in general sail with higher speeds.
- 3%, 5%, and 10%. The expert believes that some of the ships in the category may be susceptible to the incentive due to slack in their schedules. In the RoRo segment it is sometimes desired to have passings that allow for rest for chauffeurs and in such cases a short passing time is not crucial. Another example that is mentioned is the ferries between Stockholm and Finland that may not necessarily need to berth in Finland.
- 3%, 6%, and 7%. This expert mentions that the traffic to Finland is on a 24-hour roundtrip and that the suggested incentive is not an option for these RoPax ferries.

The group considers the calculated pooled distribution as representative of their gathered estimates. The joint median value is 9%, and the probabilities are best fitted to a normal distribution. The curve is presented in Figure 9.

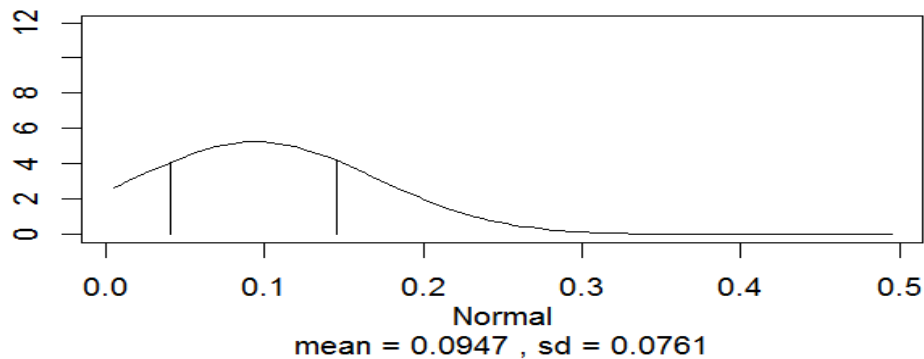


Figure 9 Agreed probability distribution, case RoRo/RoPax/Ferry ships.

In a following discussion of this incentive in the reference group the question was raised on the fees paid for pilots, and how this could be assumed to influence ship speed. When a pilot has boarded a ship the speed is generally increased since the fee for the pilot is time dependent. The prices for pilots listed by the Swedish Maritime Administration indicate that the time dependent costs for pilots in the three case study ports are small in comparison with the fuel cost savings (Swedish Maritime Administration, 2018).

3.2.3 3rd step: Emission calculations

Method

Emission calculations comprise baseline calculation on total emissions in the three participating ports, Port of Gothenburg, Ports of Stockholm and Port of Trelleborg. The most interesting emissions are NO_x emissions from ships at berth in the ports, and CO₂ emissions from ships sailing in an area within 20 NM from the port since these are the emissions that are aimed to be reduced with the incentives. Emissions are calculated based on information on installed engine power on the calling ships, estimated engine loads in different operational modes, time in different operational modes and emission factors. The emission factors are values on the emitted mass of a substance in relation to the energy output of the engine (often expressed as g/kWh). The method relies on port call statistics received from each of the three case study ports for year 2017, and ship specific data. It is further described in detail in Winnes et al., 2016.

Result: Calculations of emissions and emission reductions in the port areas

The baseline emissions of CO₂ for ships in the fairway channel and NO_x at berth in the three ports represent a scenario with no abatement measures taken. The emission quantities are presented in Table 22.

Since the investigated NO_x-incentive is not targeting the ship type category RoRo/RoPax/Ferry, the emissions from ships visiting Port of Trelleborg are not included. The Port of Trelleborg only served ships of these types at the year of the inventory. The NO_x emissions from auxiliary engines from ships at berth were in 2017 calculated to be 720 tonnes and 130 tonnes in Port of Gothenburg and Ports of Stockholm respectively. Further, although the slow steaming incentive applies to container

and RoRo/RoPax/Ferry ships in all ports the ships visiting Stockholm city ports (as opposed to Nynäshamn and Kapellskär), are not included since the archipelago necessitates slow speed on all ships in traffic in an out of the port. An incentive would not contribute to a change. The distance for which emissions are calculated is in all cases longer than the ports' traffic areas. All ports service ships in the category RoRo/RoPax/Ferry. Main engine emissions of CO₂ emissions from this category of ships in the 20 NM zone were calculated to 53 000 tonnes, 88 000 tonnes, and 85 000 tonnes for Port of Gothenburg, Ports of Stockholm and Port of Trelleborg, in that order. Emission reductions from container ships are only relevant to calculate for Port of Gothenburg since Ports of Stockholm does not have container ships in high speed in the archipelago, and Port of Trelleborg exclusively serves ships in the category RoRo/RoPax/Ferry. The container ships baseline CO₂ emissions are calculated to be 11 000 tonnes.

Table 22 Baseline emissions for the studied ports, year 2017.

Port	NO _x emissions from ships' auxiliary engines at berth (tonnes)*	CO ₂ emissions from RoRo/RoPax/Ferry ships' main engines steaming in the 20 NM zone (tonnes)	CO ₂ emissions from container ships' main engines steaming in the 20 NM zone (tonnes)
Port of Gothenburg	720	53 000	11 000
Ports of Stockholm	130	88 000	-
Port of Trelleborg	-	85 000	-

* Excluding ship category RoRo/RoPax/Ferry

The overall emissions of CO₂ and NO_x, covering both main engines and auxiliary engines and all operational modes of all ship types in the port and the 20 NM zone are presented in Table 23. The emissions in the fairway channel are dominating when the estimate covers an area of this size. In general the emissions from ships at berth contribute most to emissions in port emission inventories (Styhre et al., 2017).

Table 23 Overall emissions of CO₂ and NO_x in the three case study ports in 2017.

	Emissions CO ₂ (tonnes)	Emissioner totalt NO _x (tonnes)
Port of Gothenburg, radius 20 NM	199 000	2 770
Ports of Stockholm, radius 20 NM	189 000	2 450
Port of Trelleborg, radius 20 NM	109 000	2 030

Result – Differentiated port dues related to measures to reduce NO_x-emissions from ships at berth

At a 100% compliance with the suggested NO_x measures the reduction of emissions are calculated to 570 tonnes in Port of Gothenburg and 110 tonnes in Ports of Stockholm. This is in both cases close to an 80% reduction of base line emissions. Applying the median value agreed in the expert elicitation - 16% adherence - the resulting CO₂ emission reduction sums up to 91 tonnes in Port of Gothenburg and 17 tonnes in Ports of Stockholm. The results from calculations of NO_x emissions from auxiliary engines from ships at berth are presented in Table 24. The calculations are based on port call statistics from the port for 2017. An uncertainty analysis covering probability distributions are presented in Chapter 3.3.

Table 24 Reduction in NO_x-emissions at 16% adherence to the proposed incentive. The calculation cover only auxiliary engines and only ships at berth.

Port	Baseline NO _x -emissions* (tonnes)	NO _x -tier III emissions* (tonnes)	Reduction in NO _x -emissions at 100% of calls at Tier III levels (tonnes)	Reduction in NO _x -emissions at 16% of calls at Tier III levels (tonnes)
Port of Gothenburg	720	150	570	91
Ports of Stockholm	130	26	110	17

*Excluding ship category RoRo/RoPax/Ferry

Result – Rebate on port dues for ships in slow speed in the fairway channel

From the expert elicitation exercise on a slow steaming incentive resulted in median values of expected adherence to 34% for container ships and 9% for the ship type category RoRo/RoPax/Ferry. From this we have calculated values of emission reductions for the different ports. An uncertainty and sensitivity analysis covering probability distributions are presented in Chapter 3.3. Reductions of emissions from main engines and auxiliary engines from the ships in traffic to and from the three case study ports are presented in Table 25. We present air emission of CH₄, N₂O, NO_x, HC, PM₁₀, PM_{2.5}, and SO₂ in addition to CO₂-emissions, since these are all affected by the change in fuel consumption. Emissions from auxiliary engines experience a net increase due to the prolonged time they are operated in the area. All in all, the emissions are reduced compared to the base line, due to significant net reductions of emissions from the main engine. The CO₂ reductions are estimated to 4 300 tonnes, 5 200 tonnes, and 2 700 tonnes for Port of Gothenburg, Ports of Stockholm and Port of Trelleborg, in that order at a compliance of 34% and 9% of container ship calls and RoRo/RoPax/Ferry calls respectively.

Table 25 Calculated emission reductions (tonnes) from an incentive targeting speed reductions in the fairway channel. Based on ship traffic to and from the case study ports 2017.

Ship type category	Engine type	Port	Emission reduction (tonnes)							
			CO ₂	CH ₄	N ₂ O	NO _x	HC	PM ₁₀	PM _{2.5}	SO ₂
Container ship	Main Engine	Port of Gothenburg	2 100	0.019	0.11	50	0.96	0.69	0.59	1.3
Container ship	Aux Engine	Port of Gothenburg	-220	-	-	-3.5	-0.16	-0.063	-0.053	-0.13
RoRo/Ferry	Main Engine	Port of Gothenburg	2 800	0.019	0.13	50	0.98	0.86	0.73	1.5
RoRo/Ferry	Aux Engine	Port of Gothenburg	-400	-	-0.018	-4.1	-0.30	-0.12	-0.099	-0.25
RoRo/Ferry	Main Engine	Ports of Stockholm	5 500	0.035	0.26	69	1.8	1.7	1.4	3.5
RoRo/Ferry	Aux Engine	Ports of Stockholm	-340	-0.005	-0.015	-3.8	-0.25	-0.10	-0.085	-0.22
RoRo/Ferry	Main Engine	Port of Trelleborg	3 000	0.018	0.14	59	0.92	0.91	0.77	1.9
RoRo/Ferry	Aux Engine	Port of Trelleborg	-260	-	-0.011	-4.3	-0.19	-0.074	-0.063	-0.16
All	All	Port of Gothenburg	4 300	0.029	0.21	92	1.5	1.4	1.2	2.4
All	All	Ports of Stockholm	5 200	0.030	0.25	65	1.6	1.6	1.3	3.3
All	All	Port of Trelleborg	2 700	0.014	0.13	55	0.73	0.8	0.7	1.7

3.2.4 Concluding remarks

The overall emissions from ships in the three case study ports are not significantly affected by the suggested incentive schemes. This is exemplified by the values presented in Table 26 where the emission reduction of CO₂ and NO_x under the suggested schemes is related to total emissions. The incentive on slow speed targeting Container ships and RoRo/RoPax/Ferry ships is estimated to achieve a CO₂ emission reduction of 2-3% in the port areas. NO_x emission reductions from the same incentive are estimated to 3% of total NO_x emissions. The incentive targeting NO_x emissions from the auxiliary engines of ships accomplish NO_x reductions of comparable magnitudes; 3% in Port of Gothenburg, and 1% in Ports of Stockholm.

Table 26 Comparison of NO_x and CO₂ emissions in the two suggested programmes with total emissions in the three case study ports, year 2017.

	Emissions total CO ₂ (tonnes)	Emissions total NO _x (tonnes)	Reduced speed in fairway channel		Reduced NO _x -emission
			Reductions compared to total emissions CO ₂	Reductions compared to total emissions NO _x	Reductions compared to total emissions NO _x *
Port of Gothenburg, 20 NM	199 000	2 770	2%	3%	3% (6%)
Ports of Stockholm, 20 NM	189 000	2 450	3%	3%	1% (8%)
Ports of Trelleborg, 20 NM	109 000	2 030	2%	3%	-

** In brackets: emissions from RoRo/RoPax/Ferry are excluded.*

A rather detailed design of the suggested incentive schemes was needed in order to perform the expert elicitation exercise. This introduced limitations that the experts needed to consider in their probability estimates. It is difficult to know the influence of the incentive scheme design on the estimated results.

If the suggested scheme for NO_x had also included RoRo/RoPax/Ferry ships the expert group might have judged probabilities differently, and the estimated outcome might have indicated that more considerable reductions could be expected. Our conclusions on potential NO_x-emissions from suggested incentive program can only be said to cover ships that have low frequent visits in Swedish ports. We conclude that the overall reduction of NO_x that can be expected from this incentive is modest but if the reduction is compared to baseline emissions excluding the RoRo/RoPax/Ferry category, the effect is significantly higher (values presented in brackets in Table 26).

The suggested incentive program on slow speed was limited to only target the ship type categories Container ships and RoRo/RoPax/Ferry. These ships often have relatively high operating speeds, which is the reason that they were selected for the elicitation exercise. Discussion on other ship types would have resulted in other probabilities from the exercise and the estimates of expected emission reductions would be different.

The results from the exercise that enter the following emission calculation should thus be interpreted with knowledge of the scope of the exercise and of subjective probability assessments.

3.3 Uncertainty and sensitivity analysis – sea transport

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The results from the environmental analysis in Chapter 3.2 contain several degrees of uncertainty. Firstly, the outcome of the expert elicitation exercise is a probability distribution for the adaption of incentives rather than a single value of adaption level. Secondly, there are uncertainties in the emissions calculations as there are assumptions made regarding e.g. engine load and the current speed of ships.

Instead of using a most likely value for engine load and ship speed, a probability distribution can be used to calculate a distribution of emissions to represent the uncertainty of the results. A sensitivity analysis can also be made to show the outcome of different assumptions in the calculations. The sensitivity analysis can show what would happen in a “best case” when an incentive is fully implemented. It can also show the difference in outcome with the same incentive adaption level, but when the incentives are adapted by average emitters, low-emitting or high-emitting ships.

Uncertainty and sensitivity analysis are combined in the following chapter. Monte Carlo simulations are used to study the results by combining uncertainties in the input parameters such as incentive adaption level and engine load. Sensitivity analysis is made by carrying out the calculation with a limited number of different assumptions.

3.3.1 Environmentally differentiated port dues to reduce NO_x emissions

Baseline NO_x- emissions totals 850 tonnes from Port of Gothenburg and Ports of Stockholm. The theoretical lower bound at 100 % compliance results in total emissions of 170 tonnes⁷. The results in Chapter 3.2, with a 16 % adherence, are total NO_x-emissions of 740 tonnes.

The following two parameters are judged by experience to have the largest impact on the emission results and are chosen for the sensitivity analysis.

- What load factor is used at berth for the auxiliary engines?
- How many of the port calls will use NO_x-reducing measures?

An engine load of 40% of MCR for auxiliary engines in port has been used for the baseline results (Entec UK Ltd, 2010). The actual load differs both between ships, but also for the same ship over time depending on the ship’s activity in port (loading, unloading, hoteling). The engine load is likely between 20-60% according to literature. The uncertainty of engine load only affects emissions from ships without NO_x-reducing technologies, since the rebate is only given to those to comply with the NO_x-requirements regardless of the engine load used.

⁷ Ship categories RoRo/RoPax/Ferry are excluded since they are assumed to already comply with the rules.

Since the NO_x-emissions from auxiliary engines is a linear function of the engine load, baseline emissions will be 390-1300 tonnes (with an average of 850 tonnes) assuming that 90% of the ships have an engine load between 18% and 62%.

The expert elicitation resulted in a lognormal probability distribution for how many of the port calls that will use NO_x-reducing measures, with an expected value of 0.16 and a standard deviation of 0.22. This means that there is a 90% probability that the NO_x-emissions will be between 490-850 tonnes with the rebate, with an expected value of 740 tonnes. It is unlikely that the full theoretical potential will reach. The upper bound (95th percentile) for reductions equals 52% of port calls using NO_x-reducing measures and the lower bound (5th percentile) equals 1.7% of port calls using NO_x-reducing measures. A summary of the results can be seen in Table 27.

Table 27 Sensitivity analysis for NO_x emission with a rebate for port calls using NO_x-reducing measures for auxiliary engines.

Scenario	NO _x (tonnes)	Emissions vs. baseline
Baseline	850	-
100% of calls at Tier III levels	180	-79%
16% of calls at Tier III levels	750	-13%
5th percentile of reductions	847	-0.8%
95th percentile of reductions	490	-57%

Using Monte Carlo-simulations, some conclusions can be drawn about the uncertainty of the total results. When combining the uncertainty of current emissions (uncertainty of engine load used) with the uncertainty of how many port calls will be a Tier III levels, the average reduction is still at the same level. The range of emissions with a 10-90% probability is however 310-1200 tonnes. The uncertainty of engine load used has the largest impact of the results, but even in a situation where current emissions are low (due to low engine load) the rebate results in lowered NO_x-emissions. A graphical interpretation of the results can be seen in Figure 10 and Figure 11.

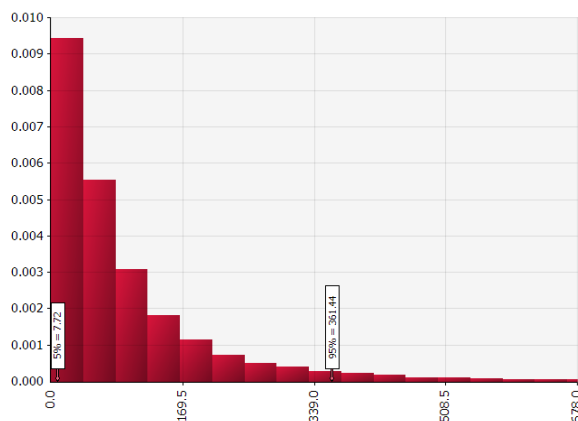


Figure 10: Probability distribution of emission reduction based on uncertainties in current emissions and adherence of proposed incentive. Expected value is 110 tonnes.

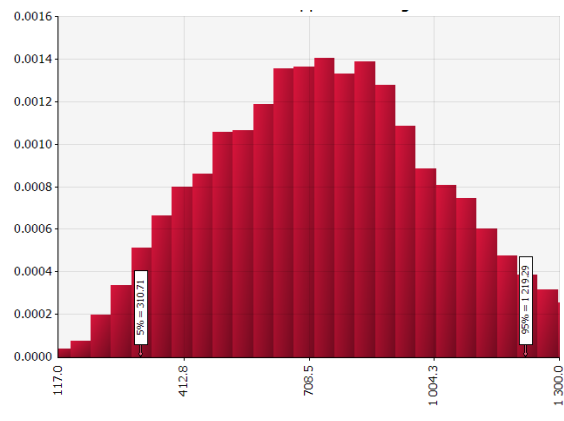


Figure 11: Probability distribution of total NO_x emissions based on uncertainties in current emissions and adherence of proposed incentive. Expected value is 750 tonnes.

Using the 16% adherence, it is assumed that the port calls will be made of ships with an average ship. A different approach to sensitivity analysis is to analyse i) if 16% of port calls with reduction measures is made by the current highest emitting ships and ii) if the most frequent ships (equaling 16% of port calls) use reduction measures. The value of such an analysis is to make first rough estimate a tradeoff between cost and benefit, since the cost consists of installation and equipment per ship. If measures used on a low number of ships can significantly reduce the total emission, there is a higher potential for cost efficient emission reductions.

The case studies Port of Gothenburg and Ports of Stockholm had 4 383 port calls during 2017. 16% of port calls responds to 701 individual calls. The 701 port calls by the highest emitters are made by 347 individual ships. The currently emit 570 tonnes of NO_x and would emit 110 tonnes if complying with Tier III levels. This equals a reduction of 1.3 tonnes/ship and year.

The 701 of port calls made by the lowest emitters are made by 93 ships. They currently emit 8.1 tonnes and would emit 2.7 tonnes if they all complied with Tier III levels. This equals a reduction of 0.06 tonnes/ship and year.

When looking at the most frequent visiting ships, 698 port calls are made by 7 ships. They currently emit 30 tonnes and would emit 5.9 tonnes if complying with Tier III. This equals a reduction of 3.4 tonnes/ship and year.

3.3.2 Discount on the port due for ships that slow down in the fairway channel

The main uncertainties for parameter which affects the result for slow steaming are:

- What share of port calls will slow down to get the discount?
- What is the current speed by ships during the final 20 NM before port?

Impact of the first parameter will be calculated for the two cases in the follow section, whereas the second parameter will only be discussed qualitatively due to lack of data. For simplicity, the sensitivity analysis will only include CO₂ and NO_x emissions.

Case study: container ships

Of the three case studies, a slow steaming rebate is only valid for container ships calling on Port of Gothenburg by previously mentioned reasons. This changes when Stockholm Norvik opens (planned for 2020) and the container port is moved to Nynäshamn. The opening of a new container port is not included in the uncertainty analysis but should be evaluated if trying to assess the impact future emissions from Ports of Stockholm.

Baseline emissions are 11 000 tonnes CO₂ and 260 tonnes NO_x from main and auxiliary engines. The lower bound of emissions (if all container ships slow down) is 5 500 tonnes CO₂ and 120 tonnes NO_x.

The expert elicitation resulted in a beta probability distribution for share of port calls that will slow down, with an expected value of 0.34 and a standard deviation of 0.23. The average emissions are then 9 200 tonnes CO₂ and 210 tonnes NO_x. From the beta-distribution, it can be derived that CO₂ emissions are between 6800-10 800 tonnes and NO_x-emissions are between 150-250 tonnes in 90% of the cases. Table 28 shows a summary of CO₂ and NO_x emissions from main engine (ME), auxiliary engine (AE) and total emissions.

Table 28 Results from uncertainty analysis of the share of slow steaming by degrees of incentive implementation.

Scenario	Engine type	CO ₂ -emissions (tonnes)	Emissions vs. baseline	NO _x -emissions (tonnes)	Emissions vs baseline
Baseline	ME	10 000	-	240	-
	AE	1000	-	16	-
	Total	11 000	-	260	-
100% of container ships slows down	ME	3 900	-61 %	90	-62 %
	AE	1 600	+64 %	26	+64 %
	Total	5 500	-50 %	120	-54 %
34 % of container ships slows down	ME	8 000	-21 %	190	-21 %
	AE	1 200	+22 %	20	22 %
	Total	9 200	-17 %	210	-18 %
5 th percentile	Total	10 800	-2,5 %	250	-2,7 %
95 th percentile	Total	6 800	-38 %	150	-42%

Case study: RoRo, RoPax and ferries

Baseline emissions are 226 000 tonnes of CO₂ and 3 800 tonnes of NO_x from all three ports. The lower bounds for emissions (all ships slow down) are 112 000 tonnes of CO₂ and 1900 tonnes of NO_x.

Experts judged it less likely that RoRo, RoPax and ferries slowed down. The probability distribution of port calls made with lowered speed was agreed to follow a normal distribution with an average of 0.095 and a standard deviation of 0.076. The average emissions are 215 000 tonnes CO₂ and 3 600 tonnes NO_x accordingly. From the normal distribution, it can be derived that there is a 90% probability that CO₂ emissions are between 203 000-224 000 tonnes and NO_x emissions are between 3400-3800 tonnes.

Table 29 Uncertainty analysis for RoRo, RoPax and ferry emissions. The table shows emissions of CO₂ and NO_x by degree of implementation of slow steaming.

Scenario	Engine type	CO ₂ emissions (tonnes)	Emissions vs. baseline	NO _x emissions (tonnes)	Emissions vs baseline
Baseline	ME	207 000	-	3 500	-
	AE	18 000	-	260	-
	Total	226 000	-	3 800	-
100% of ships in ship category slow down	ME	82 000	-60 %	1 500	-56 %
	AE	30 000	+60 %	400	+52 %
	Total	112 000	-50 %	1 900	-49 %
9.5 % of ships in ship category slow down	ME	195 000	-6 %	3 300	-5 %
	AE	20 000	+6 %	270	+5 %
	Total	215 000	-5 %	3 600	-5 %
5 th percentile	Total	224 000	-0,6 %	3 800	-0,6 %
95 th percentile	Total	203 000	-10 %	3 400	-9,9 %

The uncertainty of current operation speed during the last 20 nautical miles has not been possible to quantify. Single observations made by the ports indicate that ships in Stockholm and Gothenburg operate close to their design speed for the major part, which was assumed in the calculations. Observations in Port of Trelleborg indicate that some ships operate at a slightly lower speed already. If the operational speed is lower than assumed in the calculations, the reduction of emissions from the main engine will be lower than calculated and the increase of emissions by the auxiliary engine will also be lower. If there is available data with good data quality (e.g. AIS data), this can be a topic of analysis for the future.

3.3.3 Concluding remarks

The analysis shows that the theoretical reduction potential is large with a rebate for NO_x reducing measures for auxiliary engines, with a possibility of reducing NO_x emissions by 79% if measures are used at all port calls. It is though highly unlikely to reach the full reduction potential as the reduction is most likely to be 13% given an incentive adaption level of 16% and the reduction will with a 95% probability be below 57%. When studying the data on port calls in detail, a small number of ships makes a large share of port calls. Since the cost of NO_x reduction measures consist of both installation and operational cost, it seems likely that some ships will be more likely to install NO_x reducing measures as the total value of lower port dues increases with the number of port calls whereas the installation cost is independent of number of port calls.

Experts believe that only a low number of RoRo ships and ferries would use slow-steaming as a measure, even if given a port due rebate. It is judged that it is highly unlikely that CO₂ and NO_x emissions would decrease by more than 10%. Container ships are more likely to slow down for a port due rebate, and the total CO₂ and NO_x reductions might be as high as 40% although a 20% reduction seems the most probable.

3.4 Summary of feedback from the reference group

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3.4.1 Introduction to the interviews and methodological considerations

The reference group were very active during all phases of the project and made great efforts giving feedback on the measures presented and sharing knowledge at the four reference group meetings. At the end of the project interviews were also carried out separately with the representatives, to give them the opportunity to leave their individual opinion on environmentally differentiated port dues and the main project results. All members of the reference group were contacted, and 12 of the 14 reference group members were interviewed. A questionnaire, including a description of the measures and six questions, was sent out before the interviews:

1. What is your opinion regarding the design of the four measures being analysed in the MAI project? (description attached)
2. What positive impact do you think each action would have if they were implemented simultaneously in all Swedish ports?
3. What negative impact do you think each action would have if they were implemented simultaneously in all Swedish ports?
4. How do you think the tax / rebate affects transport setup at large (risk of sub-optimisation or positive dynamic effects, etc.)?
5. What is required for environmentally differentiated port tax to have any effects on investments in new technology or changing behaviour?
6. What principle do you generally think is best, to raise the fee for the dirtier ships / vehicles or to give a discount for the cleaner?

The purpose of collecting individual feedback from each of the reference group members was to enable the involved parties to give their views, concerns, general thoughts and standpoints related to the environmentally differentiated port dues and analysed measures. This process also minimized the risk for important views and fact not being collected.

The overall impression from the member of the references group is that there are approximately as many positive comments as negative ones. Some organisations were generally positive towards all presented measures and some predicted more negative effects in case the measures would be realised. A significant part of the feedback was related to technical framing of the proposed measures, as well as hinders, difficulties or a possible side effect that needs to be handled.

3.4.2 Feedback from the reference group

In general, the feedback from the reference group regarding the design of the four measures analysed in the MAI project is that actions need to be taken to decrease the negative impact related to shipping, both on the sea- and landside. This mean that the measures analysed would contribute to tackle the negative impact from the operations concerned. This is for example expressed as “In

general, it is four possible measures; however some technical implications can also be seen” and the fact that different measures can trigger positive effects “Generally, measures can be used to increase rail and solutions such as dry ports where goods are discharged and retrieved outside the port area and railed into the port or other solutions that create less congestion and less emissions”.

A common concern that is mentioned from almost all parties in different ways is the “Risk of steering away from shipping towards road transportation” and “Our general position is the importance of priority of rail transportation” and that it is “Important to promote rail and sea transportation”. Many parties also express the risk for negative impact on competition depending on how policy measures are constructed which is expressed for example as “If a fee is introduced, it must apply in all ports to avoid distorting competition” and “Anything that makes it more difficult for shipping can result in a shift to road transportation”. Another common comment is that the ports and terminals should not be the part that gives the rebates. Two persons for examples expressed: “We are hesitant to that private parties (ports) will be given the role as handing out rebates when it should be the state” and “The risk that private actors (ports) will be punished by loss of income, in case many clients get the rebates”.

Comments explicit towards the analysed measure **Environmental fees for trucks at the terminal gate** are divided from very positive, “Looks good. Positive that low fill-rates being penalised and that environmental friendlier vehicles being rewarded”; towards quite negative “The fee will increase cost for intermodal rail transport and lead towards road transportation”. Concerns are also raised towards the fact that “Emission performance for trucks in urban areas is not an issue solely connected to the ports and should therefore not be regulated in connection to the ports. The issue is regional or national or perhaps an EU question” and comments such as “Other regulations on a higher level would have to change the truck fleet”. There were also comments related to the overall effects in a larger perspective: “Some improvement in the fleet of trucks by larger players moving the worst trucks to other regions” or expressed as “Moving emissions to other regions by moving the dirtier trucks”.

The comments related to the instrument **Congestion fees for trucks at the terminal gate** were also both positive such as “Good control measure as it relieves the infrastructure” and negative such as “The congestion in a city is not only around the port, and it will then be irrational to punish just those trucks that call at the port”. Not all expected the measure to be efficient “For example, related to congestion in Gothenburg, there should be other more efficient instruments to reduce congestion like congestion taxes and removing bottlenecks”. However, also comments were given such as “In some cases, the additional fee for handling the goods at congestion periods will probably be accepted, but some segments are easier to influence.

The measure **Reduced speed at sea** also received both positive and negative comments, however more on the technical side. Concerns were presented if the total effect will be positive with the risk such as “Difficult to know if the ships reduce the speed close to the ports and instead compensate with higher speed at sea. This could have a negative overall impact” or expressed as “Important to check via AIS that the speed is not increased outside the control area”. Another comment was that there is a “Risk of need for more vessels”. It was also highlighted that the fees for pilotage, handled by the Swedish Maritime Administration, might work against the measure “Assumes a different fee structure for pilotage. Today the pilot fee is per hour, which drives vessels towards higher speeds”. Notes were also given related to the fact that the measure might not fit all vessels so well “This is really a difficult instrument as each vessel has a specific optimized speed and therefore it becomes problematic to have a static speed-limit that all vessels should follow”. Other concerns were “If you take a specific ship that for example transport forest products from Sweden on the loop with a number of vessels, the entire service is optimized for a specific speed. Should the speed be reduced to/from Swedish ports, speed would need to be increased outside that area to maintain service, which would result in increased total consumption. The important thing is to improve the total picture” and “The instrument is complicated, and the conditions are very different for different ports. For

RoPax, the possibility of reducing speed is probably low as the entire transport setup would be set aside". Also worries if the measure will trigger change were expressed such as "Difficult to determine if the measure will provide increased effects as there are already today financial incentives to slow down".

The measure **NO_x-rebate for ships at berth** is a measure that in principle all parties supports and gave almost only positive comments such as *"Corresponding systems already exist with NO_x discounts on port dues since the 80s which work well"* and *"This instrument includes more ships than those who need to meet future NECA requirements, which can create a positive change"*. The concerns were more related to how effective the measure would be if only applied in Swedish ports *"Difficult to assess if changes in engine emission performance will happen in case the instrument is only implemented in Sweden"*. But also, that the measure *"Perhaps could give leverage effects"*. There were also thoughts about the similar systems already in place and the efficiency of the same *"The NO_x discounts that have existed over time have had most symbolic value and did not really change the performance"*. On the technical construction of the assessed measure comments were also made such as *"The new NECA requirements from 2021 stipulate 2 g NO_x/kWh, and this requirement should be harmonized with this. Therefore, do not introduce a new limit of 3 g NO_x/kWh"* and *"Founding that the level 3 g/kWh would provide a discount for vessels that exceed the future statutory Tier III level of 2g/kWh"*.

The general thoughts are straight forward related to the question: **What is required for environmentally differentiated port taxes to have any effects on investments in new technology or changing behaviour?** The answers were typically that *"The instrument needs to be large enough to affect the company's business / company's financial estimates significantly"* or expressed as *"The incentive must be so high that you gain from the investment or the change behaviour"*. Related to the willingness to change it was also stated that *"Perhaps starting to see effects at the proposed levels, however, to achieve powerful effects, greater measures are required. In many cases, it will depend on the value of the goods. Forrest products cannot withstand much higher costs while high-quality goods may not be affected at all"*. A comment related to the likeliness of the instruments making a change was made: *"Today, NO_x cleaning equipment is actually installed and available on board some vessels but are yet not used due to the fact that the operational costs are too high. It needs to be a worth it from a strict company business perspective"* and *"Linked to the current discount system, no container vessel calling at our port has taken any measures to reduce NO_x lower than required. Today's incentive levels must be too low"*. A comment from a business perspective was: *"Measures are taken in the first place if there are laws or other requirements (compliance) or that, in terms of energy efficiency, is profitable. Minor measures / costs can be taken linked to environmental benefits caused by the measure"*. Comments were also made related to how different incentives interact: *"Important with long-term perspective. Combined effects of different instruments may also make a difference; such as discount given in all ports that the vessel calls at"*. The robustness of the index and the possibility to foresee the effects was commented such as *"Important, for example, discounts are predictable inasmuch as they are not a pot and may end"*. But also comments such as *"The four instruments can, together with other existing instruments, give a greater overall effect"*.

At the end of the interview the respondents answered the question: **What principle do you generally think is best, to raise the fee for the dirtier ships / vehicles or to give a discount for the cleaner?** Most representatives from the reference group thought that a mix was needed, *"Both whips and carrots. Only fees are no success. Important to show that you support a development."* with some varies in what should be used for different occasions. There were also arguments given on when to apply the different means such as: *"As a port, you have a customer relationship with shipping companies and cargo owners, and then discounts can feel more natural to work with than fees that are perceived more as punitive. On the other hand, authorities should be able to more easily use fees that may be more effective"*.



3.4.3 Conclusions from the interviews

The reference group participated actively, contributed and gave important feedback on proposed instruments. Before the interviews, some of the respondents had also anchored the response in advance within their own organisations. In total approximately a quarter of all the answers were positive, a quarter negative and half of the response where neutral towards the proposed instruments and instead included thought on changes and clarifications.

4. Impacts of different national infrastructure fees and taxes

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Chapter 4 focuses on the national perspective and comprises impact analyses of different national infrastructure fees and taxes. Section 4.1 evaluates the effects of the environmentally differentiated fairway dues that were in place in Sweden 1998 - 2017 in an ex-post analysis. Section 4.2 studies the impact of planned and discussed revisions/implementations of different national fees and taxes in an ex-ante analysis.

4.1 Impacts of Sweden's environmentally differentiated fairway dues⁸

4.1.1 Introduction

The Swedish Maritime Administration (SMA, Sjöfartsverket) is responsible for developing policies which reinforce and support government objectives and decisions. The duties of the SMA include maintaining the fairways, providing pilotage, ice breaking and maritime rescue services and acting to minimize the impact of shipping on the environment. The SMA is responsible for determining and collecting fairway dues that shall be paid for vessels that load or unload cargo (or passengers) in Swedish ports. The size of the vessel, its cargo (or number of passengers) and its emission of air pollutants shall be considered when determining the fee. The revenue raised from the fairway dues is the largest source of income for the SMA. It is used to cover the costs associated with the maintenance of the fairways and activities such as ice breaking (for which there is no specific fee). Pilotage fees cover largely the costs for providing pilot services. The fairway dues consist of two parts: one calculated based on the vessel's gross tonnage (GT) and one based on the cargo that is loaded or unloaded. An important feature of the system is that it should be consistently as revenue-neutral as possible.

In 1996 the SMA, the Swedish Shipowners Association and the Swedish Ports and Stevedores Association reached a tripartite agreement to reduce the air pollution from sea transport. The parties set a target to decrease the NO_x and SO_x emissions to air sourced from vessels that call at Swedish ports by 75 % within five years. For SO_x and NO_x emissions, the SMA introduced differentiated fairway dues in 1998 and several ports implemented port dues with a similar environmental differentiation. The system of the SMA ended at the end of 2017 and from 2018, a new system was implemented whereby fairway dues are differentiated according to several, more varied and holistic, environmental aspects.

⁸ Section 4.1 is based on Tobias Lindé and Inge Vierth, An Evaluation of the Environmentally Differentiated Fairway Dues in Sweden 1998–2017, (VTI Notat 3A/2018)

For most of the period 1998 to 2017, fairway dues in Sweden were differentiated on the basis of both SO_x and NO_x emissions. However, the implementation of the International Maritime Organization (IMO) sulphur directive in 2015, with stricter requirements within the sulphur emission control area (SECA) of the Baltic Sea, North Sea and English Channel areas, made the differentiation of fairway dues on the basis of SO_x emissions redundant. Despite the presence of a system of environmentally differentiated fairway dues in Sweden for the past 20 years, there have been relatively few evaluations of the long-term impact and effects of the policy instrument. Several evaluations were carried out in the years after the implementation, (SMA, 2000), MariTerm (1999), Kågeson (1999) and Swahn (2002). More recently, Transport Analysis (2017) undertook a study with a focus on predicting the potential environmental effects of the new fairway dues system, introduced in 2018.

The data which underpins the analysis below is derived from regulations; SMA's annual reports; other available data, sources of information and literature, all of which has been supplemented with personal communications with the SMA and other authorities. The information collected has been systematically analysed to present the development of Swedish fairway dues and their impacts over time. Every SMA fairway dues regulation which has been issued contains information regarding which regulation it replaces, and it has thus been possible to track the main changes in the fairway dues regulations from the introduction of the environmentally differentiated fairway dues in 1998 to the system as it stood at the end of 2017.

To further promote the installation of NO_x reducing catalysts on vessels, refunds were given of fairway dues paid during the year of approval and for the following four years. These refunds amounted to up to 40% of the investment costs for catalysts approved by the SMA before 2000 and 30% for those approved after 2000. After 2000, similar refunds were given for the installation of humid air motor (HAM) equipment. The refunds were removed after 2001 because it was considered too costly.

Table 30 illustrates the evolution of the fairway dues 1997-2017, showing that the NO_x and SO_x emission levels that were required to be eligible for reduced dues became stricter over the years:

- The sulphur content limit for reduced fees was 1% when the differentiation was introduced in 1998 and then decreased to 0.5% in 2008, before the sulphur fee was removed altogether in 2015, when the sulphur limit in the SECA was lowered to 0.1%. The maximum discount for using low-sulphur fuel evolved from 0.90 SEK in 1998 to 0.60 SEK in 2005 and then finally to 0.70 SEK from 2008 until 2015.
- Reduced GT fees started at below 12 g NO_x per kWh in 1998, but this limit decreased over time to become 6 g/kWh in 2017. The limit for the lowest fee also decreased from 2 g/kWh to 0.49 g/kWh. Meanwhile, the maximum amount that could be saved by reducing NO_x emissions increased. In 1998, the difference in the fee for vessels with emissions above the upper limit (12 g/kWh) and below the lower limit (2 g/kWh) was 1.60 SEK per GT and in 2017 the difference for vessels above the upper limit (6 g/kWh) and below the lower limit (0.49 g/kWh) was 2.75 SEK.⁹

⁹ Once fairway dues had been paid 18 times within a calendar year for a passenger vessel or rail ferry (or 12 times for other vessels), any subsequent fairway dues payable within the calendar year were based on the cargo only.

Table 30 Limits and discounts for the fairway dues 1997-2017.

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	
Cargo fee	Yes																					
GT fee	Yes																					
GT NO _x , maximum discount (SEK)					1.6				1.20			2.05						2.55		2.75		
GT NO _x , upper limit for discount (g/kWh)					12							10						6				
GT NO _x , lower limit for discount (g/kWh)					2							0.4								0.49		
GT SO _x , maximum discount (SEK)					0.90				0.60			0.70										
GT O _x , deductions below (O _x content)					1.0%						0.5%											
Refunds for installation of catalysts			Yes																			
IMO NO _x limit for new vessels (g/kWh)*			9.8 - 17.0*												7.7 - 14.4							
IMO SECA SO _x limit (SO _x content)												1.5%			1.0%					0.1%		

Indicates that during the whole period the fairway dues consisted of one part based on the cargo and one part based on the GT of the vessel.

Shows the environmentally differentiated parts of the fee that depend on NO_x emissions and the SO_x content in fuel, as well as in which years refunds were given for installing NO_x reducing techniques.

Show the NO_x limits for new vessels and the SECA sulphur limit, as established by the IMO.

Source: Compiled from annual reports of SMA (1997-2017) and International Maritime Organization (2017a, 2017b, 2017c).

4.1.2 Impact on SO_x emissions

As shown in Table 30 the discount for vessels with a SO_x reduction certificate has been in the range of 0.60-0.90 SEK per GT and per port call during the whole period of analysis. The values are presented in Figure 12, where the total annual discount value ranges from 22 to 40 million SEK. This means that the average discount received by an individual ship operator has varied between approximately 20,000 SEK to 60,000 SEK per year. Over the years, therefore, the total value of the discounts given have amounted to approximately 3% of the total revenues raised from fairway dues.



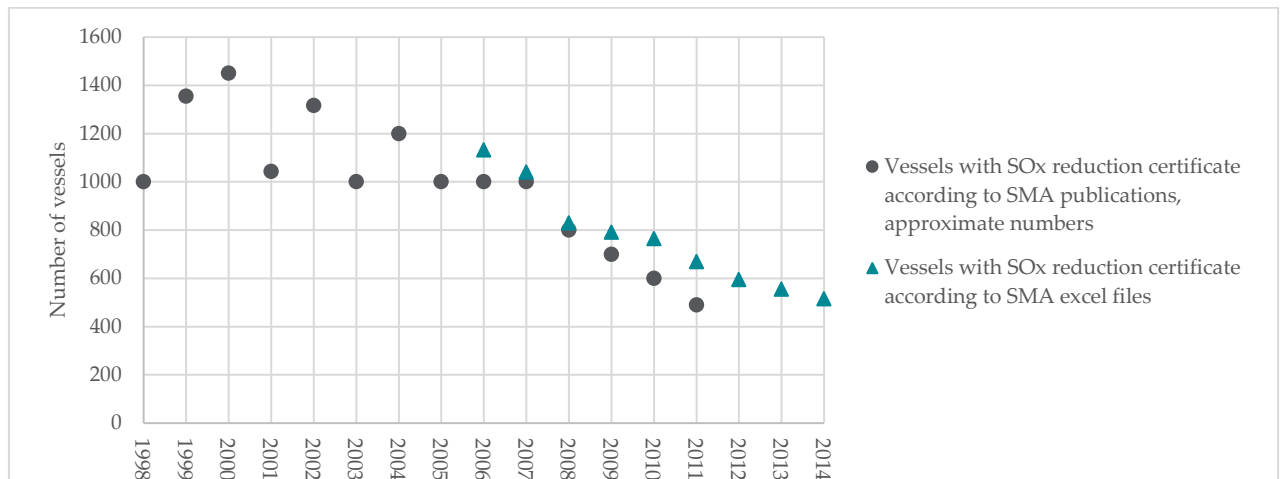
Source: Derived from the annual reports of the SMA (1998-2014).

Figure 12 Annual total values of SO_x discounts given to vessels with SO_x reduction certificates 1998-2014.

There are several measures that vessel operators can take to reduce SO_x emissions. However, by far the most obvious and most implemented measure is to change to a fuel with lower sulphur content. According to Kågeson (1999), this requires no adjustments to the propulsion system and can actually reduce operating problems in the engine. Clearly, the cost of reducing SO_x emissions by switching fuel is directly related to the difference between the prices of low and high sulphur fuel and will change over time with changes in this spread.

By December 1999, the number of vessels that had been granted lower fairway dues for using low-sulphur fuel was 1,355 (SMA, 2000). According to MariTerm (1999), most of the vessels that received SO_x reduction certificates were already using low-sulphur fuel and the number of vessels that acted and switched to low-sulphur fuel because of the introduction of sulphur differentiated fees was estimated to be in the interval of just 150-440. This supports the assertion of Swahn (2002) that the rapid increase in the number of vessels with low sulphur certificates in 1998 was due not only to the effect of vessels switching to low sulphur fuel, but also to the registration of vessels that were already using low sulphur fuel.

The annual number of vessels with SO_x reduction certificates is presented in Figure 13. After an initial rapid growth, the number of vessels with SO_x reduction certificates has steadily decreased over the years, from 1,450 in the year 2000 to approximately 500 in 2014 (the final year with SO_x differentiated fairway dues).



Source: SMA excel files and annual reports of the SMA (1997-2017)¹⁰

Figure 13 The number of vessels with SO_x reduction certificates 1998-2014.

SMA (2005) highlights the difficulties in assessing which fuels have been used by ships and the problem of geographical demarcation when estimating emissions from shipping. Nonetheless, a rough estimation of the reduced SO_x emissions from the certified vessels is provided. The reduced emissions from the 1200 vessels with SO_x reduction certificates in 2004 was estimated to be approximately 50 000 tonnes, compared to if the vessels had used fuel with a normal sulphur level. However, the assumed normal sulphur content of fuel has not been specified and, a significant

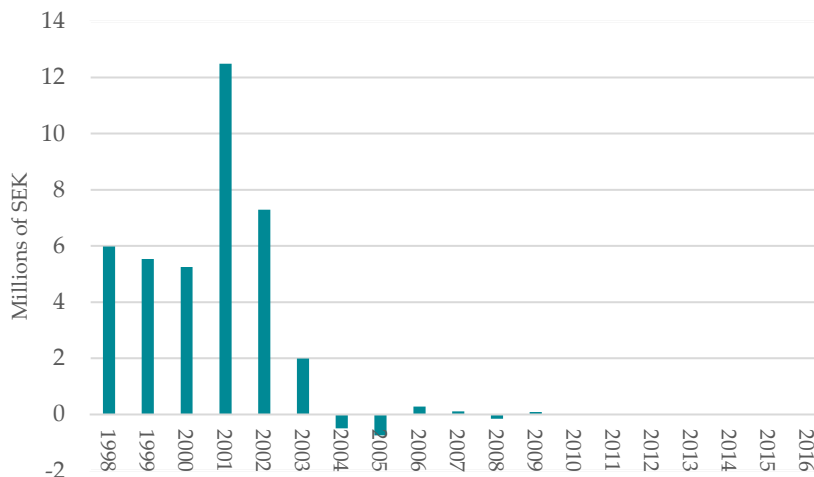
¹⁰ The annual reports of SMA sometimes indicate an approximate number of certified vessels and sometimes a specific number, whereas the excel/data files always contain specific numbers and this could explain some of the divergence in certain years between the two sources.

number of vessels were probably using low sulphur fuel even before they received SO_x reduction certification. Furthermore, several other official reports provide the same estimated reduction of 50 000 tonnes per annum, even though the number of certified vessels has varied over time (for example, 1450 vessels reported in SMA (2001) and just over 1000 in SMA (2006)). This emphasizes the uncertainty surrounding this estimate but, in the absence of alternative estimates of the volume of reduced SO_x emissions from certified vessels, it does give an indication of the scale of improvement achieved.

4.1.3 Impact on NO_x Emissions

Unlike the case of SO_x discounts, the actual total amount of discounts given to vessels with a NO_x reduction certificate have not been reported separately in the annual reports of the SMA. However, SMA (2015) reports that the total amount of NO_x discounts to the certified vessels in 2014 amounted to 58 million SEK. While this corresponds to an average discount per certified vessel of approximately 1.5 million SEK, the report states that 15 of the vessels received 90% of the total amount, meaning that these 15 vessels received average discounts of 3.5 million SEK.

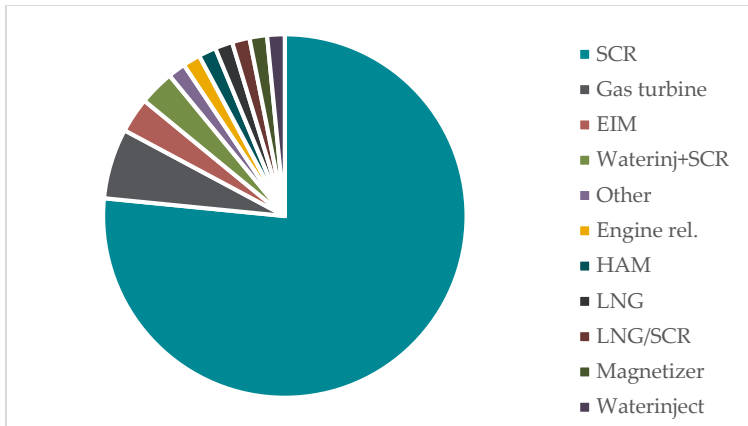
While the NO_x discounts have not been reported separately by the SMA, the refunds given for investments in NO_x reducing installations have been reported and are shown in Figure 14. During the early years that they were given, these refunds were approximately five to six million SEK per year. Refunds were still given following the cut-off date at the end of 2001, on the basis that refunds could be claimed up to four years following installation.



Source: Derived from the annual reports of the SMA (1997-2017).

Figure 14 Total annual value of refunds paid by SMA for investments in NO_x reducing installations 1998-2016.

Figure 15 shows the different measures taken by the vessels that had a NO_x reduction certificate in any year during the period 2007-2016. The installation of Selective Catalytic Reduction Technology (SCR) has been the most popular measure to reduce NO_x emissions over the period analysed.

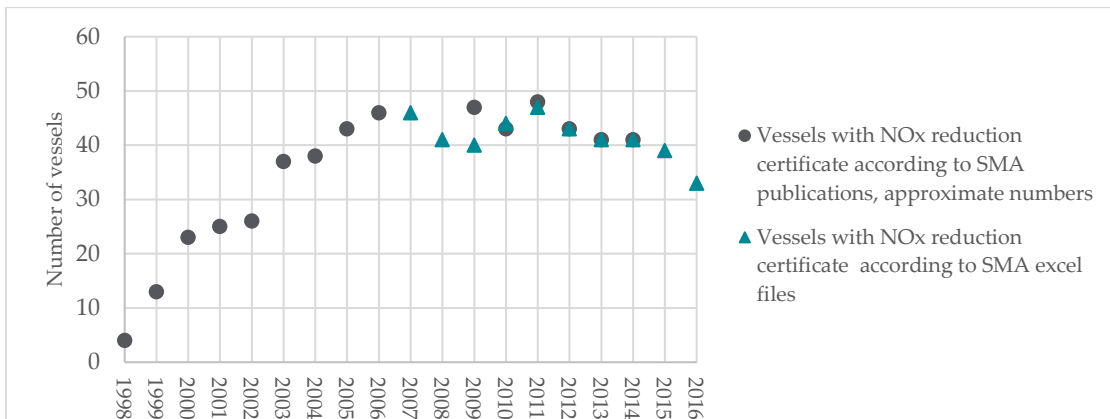


Source: Compiled by the authors based on SMA excel files.

Figure 15 Measures taken to reduce NOx emissions by 64 vessels that had a NOx reduction certificate in any year over the period 2007-2016.

At the end of 1999, 13 vessels had received a NOx reduction certificate. Nine of these vessels had taken deliberate action to reduce emissions in order to gain certification. According to Kågeson (1999), seven had installed SCR and two used water injection. The other four vessels with NOx reduction certificates already had NOx emission levels below 12 g/kWh (MariTerm, 1999). This highlights the fact that the number of certified vessels cannot be assumed to be solely a causal effect of the introduction of NOx differentiated fairway dues; some vessels already met the required low emission level for certification.

Figure 16 shows that the number of vessels with NOx reduction certificates increased steadily during the first years after the introduction of NOx differentiated fairway dues (during which time refunds were also given for NOx reducing techniques). Over time, the growth rate has declined until a plateau of 40-48 certified vessels was reached between 2005 and 2014. In recent years, the number of certified vessels has declined and was 33 in 2016.



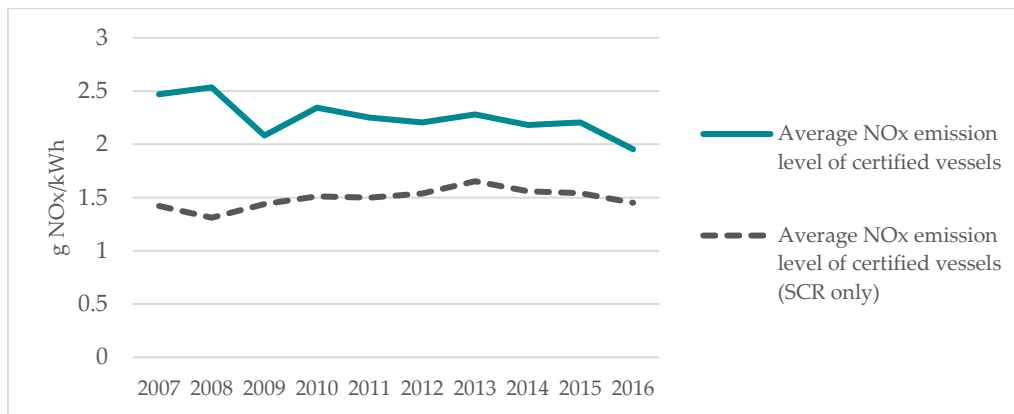
Source: Derived from SMA excel files and annual reports of the SMA (1997-2017).¹¹

Figure 16 The number of vessels with a NOx reduction certificate 1998-2016.

¹¹ Data is compiled based on SMA’s publications and data files and the slight differences during some years could depend on whether SMA-owned vessels are included or not and on how vessels that had a certificate for only a part of the year are accounted for.

When studying the evolution of the number of certified vessels, one must also consider that the conditions to receive a NO_x certificate have changed over time (as was shown in Table 30). The emission levels necessary to receive a NO_x reduction certificate have decreased from 12 g/kWh to 6 g/kWh, making it more difficult to obtain a certificate. Simultaneously, the potential savings from reduced fairway dues have increased over time from 1.6 SEK per GT in 1998 to 2.75 SEK per GT in 2017.

The average per vessel NO_x emission level of certified vessels decreased slightly from approximately 2.5 g NO_x per kWh in 2007 to less than 2 g/kWh in 2016. For certified vessels with SCR installed, the average emission level has been lower and rather stable at around 1.5 g/kWh. This differs from the often-quoted theoretical level of reduction of 95 % (Kågeson, 1999; SMA, 2009). One explanation for this difference is provided by Grundström (2017) who suggests that the emissions level reported on the NO_x reduction certificate is the average emission level of all the vessel's engines, and that this level will be higher than the theoretical level if SCR technology is only installed on the main engines and not on the auxiliary engines.



Source: Compiled by the authors from SMA excel files.

Figure 17 NO_x emission levels of the vessels with NO_x reduction certificates 2007-2016.

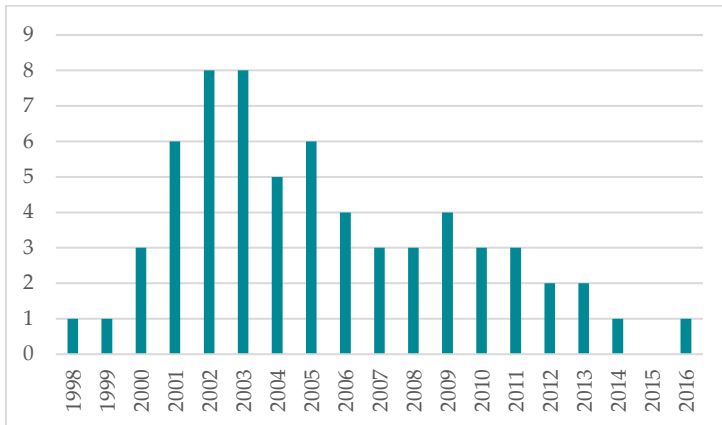
Using the same categories as in Vierth (2016), the vessel types and GT groups of vessels that had a NO_x reduction certificate in any year during the period 2007-2016 is presented in Table 31. The total number of unique vessels that had a certificate is 64, indicating that each year a large fraction of the certified vessels is the same as in the previous year. Ro-pax was the most common vessel type, representing more than 45 % of the certified vessels. Ro-ro was the second most common vessel type, followed by tanker.

Table 31 Number of vessels that had a NO_x reduction certificate any year during 2007-2016 by vessel type and GT.

GT Vessel type	3 900-11 500	11 500-26 500	26 500-53 000	53 000-85 000	85 000-140 000	Total
Dry cargo	1					1
General cargo	2					2
Other	2					2
Ro-pax	10	2	11	5	2	30
Ro-ro	6	10	1			17
Tanker	10	2				12
Total	31	14	12	5	2	64

Source: Compiled by the authors using SMA excel files and the classification of vessel types and sizes in Vierth (2016).

Most of the vessels that had a NO_x reduction certificate in any year during the period 2007-2016 received their first certificate before this period, with a peak at around 2002-2003, as can be seen in Figure 18. Even in 2015 and possibly even earlier, the SMA planned to change the system and differentiate fairway dues in accordance with an index, which implied that NO_x emissions would only be one of several criteria and, hence, the financial incentives to reduce NO_x were expected to decrease (SMA, 2015). This expectation has been reflected in the reality of a relative absence of newly certified vessels in recent years. Nonetheless, one vessel was certified for the first time in 2016, possibly for other reasons or because a decision on investment had already been taken.



Source: Compiled by the authors from SMA excel files.

Figure 18 Year of approval of first NO_x reduction certificate for vessels that had a NO_x reduction certificate in any year during 2007-2016.

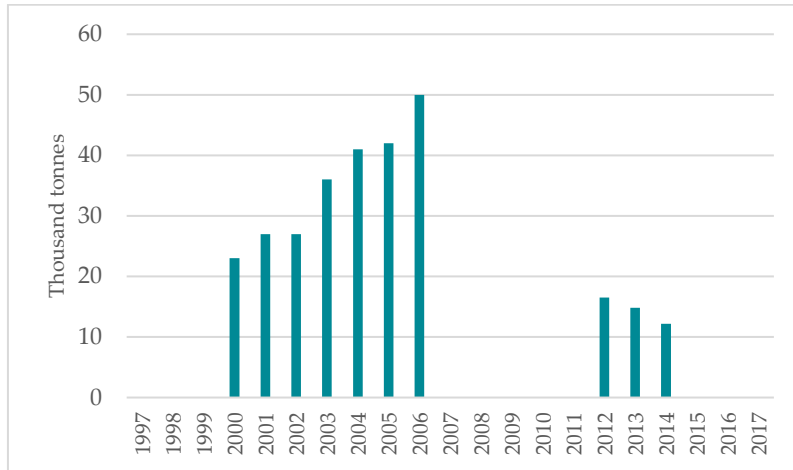
The NO_x reduction certificate contains information on the measured NO_x emissions level and the nominal power output of the vessel. When this information is combined with information or assumptions on the running time and/or distance sailed and the level of vessel emissions before certification, the amount of NO_x emissions reductions for each vessel can be estimated. SMA (2005) estimates that the reduction of NO_x emissions from the 38 vessels that had a NO_x reduction certificate in 2004 was 41 000 tonnes. Similar estimates for the years 2000-2006 are provided in SMA’s annual reports and these numbers are presented in Figure 18.

On behalf of the SMA, for the years 2012-2014 the Swedish Meteorological and Hydrological Institute calculated the reduced NO_x emissions from certified vessels based on the use of AIS-data¹² (SMHI, 2016). Together with the emission levels that are reported in the NO_x reduction certificates, the reduction of NO_x emissions from certified vessels can be better estimated utilizing this source of data. SMA (2013) reports an estimate for the reduced NO_x emissions from the 43 vessels with a NO_x reduction certificate in 2012 to be 16 526 tonnes. This is for voyages undertaken in the Baltic Sea, Skagerrak and the Kattegat areas, with the assumption that the average emission level per vessel would otherwise have been 14 g NO_x /kWh.

A similar report (SMA, 2016) provides the corresponding estimates for the years 2013-2014, with the assumption that emissions would otherwise have been according to the IMO requirements. The reported reduction in NO_x emissions from vessels with a NO_x reduction certificate increased steadily from 23 000 tonnes in 2000 to 50 000 tonnes in 2006. As can clearly be seen in Figure 19, the reported reductions in NO_x emissions are considerably lower during the period 2012-2014, when the more

¹² Using AIS (Automatic Identification System) data, the exact positions of each certified vessel can be obtained and hence the actual running time, kilometers sailed, speed and geographical location can be accounted for in the estimations.

precise estimation method based on AIS data was used and the geographical area was limited to the Baltic Sea, Skagerrak and the Kattegat areas. For the period 2000-2006, the reported average reduction in NO_x emissions per certified vessel was 1030 tonnes and the corresponding figure for the period 2012-2014 was 348 tonnes.

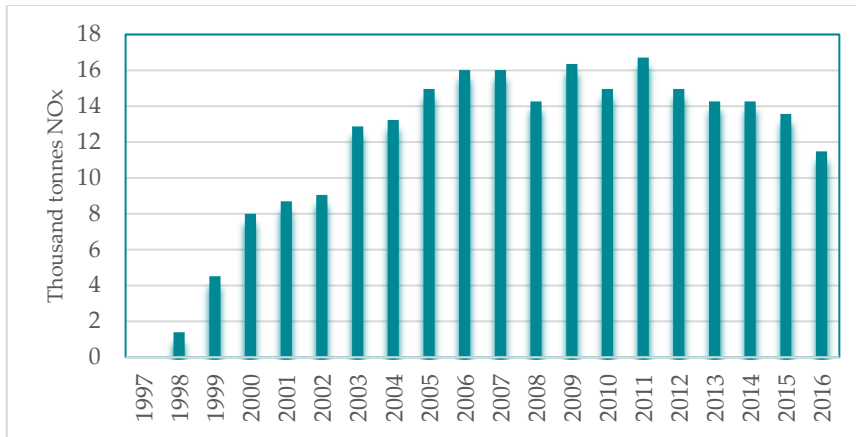


Source: Derived from the annual reports of the SMA (1997-2017).

Figure 19 Reductions in NO_x emissions achieved by vessels with NO_x reduction certificates.

Despite the absence of estimates for NO_x emissions reductions for much of the period, Figure 20 presents an attempt to show the evolution of reduced emissions over time. By combining the information on average NO_x reduction per certified vessel in the period 2012-2014 with the number of certified vessels for each year in the period 1998-2016, the reductions in NO_x emissions per year can be estimated for the whole period. The annual estimates presented, therefore, are fundamentally based on the more precise SMA (2013, 2016) estimations using AIS data where voyage activity is restricted to the Baltic Sea, Skagerrak and the Kattegat areas. According to these estimates, the reduced NO_x emissions from certified vessels have been in the range 11 000-17 000 tonnes per year in this area during the period 2003-2016. The assumptions underpinning this extrapolation are that the vessel types, sizes and transport routes remain similar over time.¹³

¹³ The limited number of unique vessels with a NO_x certificate in any single year during the period 2007-2016 means that a large proportion of the certified vessels in any one year is the same as in previous years and, hence, this set of assumptions should hold to some extent at least.



Source: Estimations based on Figure 16 and SMA (2013, 2016).

Figure 20 Estimation of approximate amounts of reduced NO_x emissions from certified vessels operating in the Baltic Sea, the Skagerrak and the Kattegat areas (based on 348 tonnes per vessel).

4.1.4 Costs versus benefits for society

The benefits for society of reducing both SO_x and NO_x emissions to air have been found to exceed the costs. However, even with environmentally differentiated fairway dues in place, reducing these emissions has not been economically profitable for many ship owners/operators.

SMA has recognised that the incentives to reduce NO_x emissions seem to be too low (SMA, 2013). Similarly, in their report on the consequences of the (then suggested) new fairway dues system, Transport Analysis (2017) also finds that the incentives in the past fairway dues system were too low for vessel operators/owners to invest in NO_x reducing techniques. This is primarily because the discounts received would contribute to only a relatively small part of the costs of catalytic equipment etc.¹⁴

From the perspective of undertaking an economic evaluation, an important question in the context of estimating the benefit to society of reduced SO_x and NO_x emissions is which emissions should be included in the calculation. For example, the calculated benefits would be much lower if only the emissions in Swedish territorial waters are considered, rather than those in the Baltic Sea, Skagerrak and Kattegat areas. The absence of estimations of total and reduced emissions using the same method and geographical demarcation makes it difficult to evaluate how far environmental objectives are being achieved (such as the goal of reducing SO_x and NO_x emissions by 75%).

The impacts and effects presented above should not be perceived as being solely the causal effect of the environmentally differentiated fairway dues. Some ship operators had already taken measures to reduce emissions before the differentiated fairway dues were introduced. Furthermore, the implementation of environmentally differentiated port dues in some ports presumably also

¹⁴ Furthermore, Transport Analysis goes on to suggest that in the system implemented in 2018, the discounts given will cover an even smaller share of the abatement costs and, hence, the incentives to reduce NO_x emissions will be even lower.

contributed to influencing the decisions of ship operators to reduce emissions, even though ports are, like the SMA, also effectively limited to implementing revenue-neutral schemes by virtue of the pressures exerted by port competition.

This yields a potentially interesting extension of the analysis above; to determine to what extent Swedish ports have implemented environmentally differentiated port dues and how these have interacted with fairway dues to influence decisions on reducing ship emissions. This is particularly relevant for the international applicability of these forms of market-based approaches since, as pointed out in van Essen et al. (2012), not all countries impose fairway dues and only a few (Estonia, Finland, Latvia, Denmark and Sweden) do so at a national level.

4.2 Impact of different taxes and fees on choice of ports and transport chains

4.2.1 Introduction

There are several policy instruments that may be applied in order to reduce emissions to air from freight transport, e. g. the internalization of external costs. Tavasszy et al. (2016) analysed the impact of internalization on global supply chains, production and trade as implemented through potential global emission trading systems or local transport charges. The authors find that the effects are generally small, but can be significant for specific sectors, e.g. agriculture and mineral fuels.

Being important interfaces in the freight transport system, ports apply different types of fees to reduce emissions at sea and on the landside. Bergqvist and Egels-Zandén (2012) study the different attitudes of stakeholders to environmentally differentiated port dues related to hinterland activities. They find that the implementation of this type of port dues has the greatest probability to be implemented (i) in situations where modal shifts require substantial infrastructure investments, (ii) in ports with congestion in the hinterland and (iii) in publicly owned ports. Gonzalez-Aregall et al. (2018) argue that the reduction of emissions to air and other externalities caused by inland transport is at least partly the ports' responsibility. They find that about 20% of 365 ports across the globe have implemented 165 measures in total to improve the environmental performance of their inland transport. Ten of these measures are pricing measures, with the objective to promote modal shift and intermodality (four measures), to reduce emissions to air (five measures) and to reduce land congestion (one measures). Bäckström (2018) discusses a hypothetical gate fee of SEK 200 per truck in Swedish ports¹⁵, see further Chapter 3.1.5 Possible regulation structures.

The analysis below relates to Sweden, where national infrastructure fees and taxes based on marginal external costs has either already been, or is under discussion to be, applied. The objective is to determine the impacts of the infrastructure fees (including port dues) and taxes, one by one and in combination, on the choice of the freight transport chains that comprise the different modes, ports and other terminals. The focus of the analysis is on long-distance freight transport in Europe where the sender and/or receiver are located in Sweden. Typically, this category of transport is more regular and repetitive than overseas transport movements. Of all tonne-kilometres moved in Sweden,

¹⁵ 1 € corresponds roughly to 10 SEK.

roughly 20% relate to transport chains that involve a transfer to/from a vessel or ferry in a Swedish port.

Analysed policies

The following actual and potential policy instruments are analysed in isolation and in combination:

- 1) An increase of about 5% higher fairway dues and 8% higher pilot fees, that have been put in place since 1 January 2018 (Sjöfartsverket, 2017).
- 2) An increase of 40% in rail track fees that is planned for implementation in 2025 to cover the external costs of wear and tear, accidents and noise, greenhouse gas emissions and air pollution by rail transport (Trafikverket, 2013). The increase for rail freight transport specifically is based on an estimation made by Westin (2018).
- 3) Implementation of kilometre-based road user fees for trucks of 0.6 to 1.1 SEK per km instead of the existing Eurovignette, as proposed in a government investigation (Regeringskansliet, 2017).
- 4) The implementation of hypothetical gate fees of SEK 50, 100, 200, 300, 500 and 1000 per truck passage in all Swedish ports, based on Bäckström analysis in Chapter 3.1
- 5) The implementation of hypothetical gate fees of SEK 50, 100, 200, 300, 500 and 1000 per truck passage in specific ports based on Bäckström analysis in Chapter 3.1

The same relative increase in taxes and fees is assumed across all commodities carried. Predicted changes in supply chains are the outcome of a modelling process, as are the changes in the environmental impacts due to changes in the supply chains. The model assumes the use of the same 33 vehicle and vessel types, as well as the same fuel or energy source, under each of the scenarios tested both before and following the implementation of the policies analysed.

4.2.2 Methodology

Samgods model

The Swedish national freight transport model Samgods (de Jong and Baak, 2016) is used to simulate the impacts of the different policy instruments one by one and in combination.¹⁶ The model consists of several components (see Trafikverket (2016) for details). Some fundamental characteristics of the model are as follows:

- (i) Production consumption matrices (PC-matrices) describe the transport demand between production and consumption locations within, into, out from and through Sweden for 34 commodities in tons. The PC-matrices are assumed to be constant, i.e. they do not decrease due to higher transport costs.
- (ii) The infrastructure network has more than 25,000 nodes and 70,000 links.
- (iii) There are 33 different vehicle types: five road, eight rail, 21 sea and one air. For sea transport, there are different types of vessels (container, ro-ro and other cargo ships) and ferries (road, rail) are included. Different average speeds are assumed for different vehicle/vessel types.
- (iv) The various logistics costs are divided into three groups: transport, warehouse and order costs. Transport costs comprise underway costs and transfer costs. The underway costs

¹⁶ Model version 1.1 is applied.

in turn comprise time-based costs and distance-based costs, as well as infrastructure fees and taxes.

- (v) An optimization routine that minimizes the shippers' annual logistics costs and transforms the commodity specific PC-flows into vehicle type specific origin-destination flows (OD-flows). The OD-flows can move directly from P to C or via one or more terminals. The economies of scale aspect is handled using different vehicle sizes.

Within the logistics model, the annual logistics costs of firms are minimized, taking into consideration the trade-off between transport costs and warehouse costs. The fact that the transport costs per unit can be reduced by using larger vehicles when transporting goods from one or several shippers is considered as well. Transport costs per vehicle-kilometre are used as inputs; load factors and costs per ton-kilometre are computed. The choice between predefined container and non-container transport chains is modelled. It is assumed that transport companies pass cost changes on to shippers. Infrastructure restrictions are also accounted for, in the form of maximum depth for vessels, maximum weight for trucks and maximum number of trains per track for rail. Capacity problems in ports are assumed to be negligible.

Output variables

Both the effects on the modal split (measured in tonne-kilometres) and the throughput (in tonnes) in the ports on the 14 stretches of the Swedish coast are calculated for the baseline scenario and the investigation scenarios that comprise different policy instruments. Because of their participation in the MAI project, particular attention is paid to the ports of Gothenburg in the West of Sweden, Trelleborg in the South and Stockholm in the East (see Figure 21).

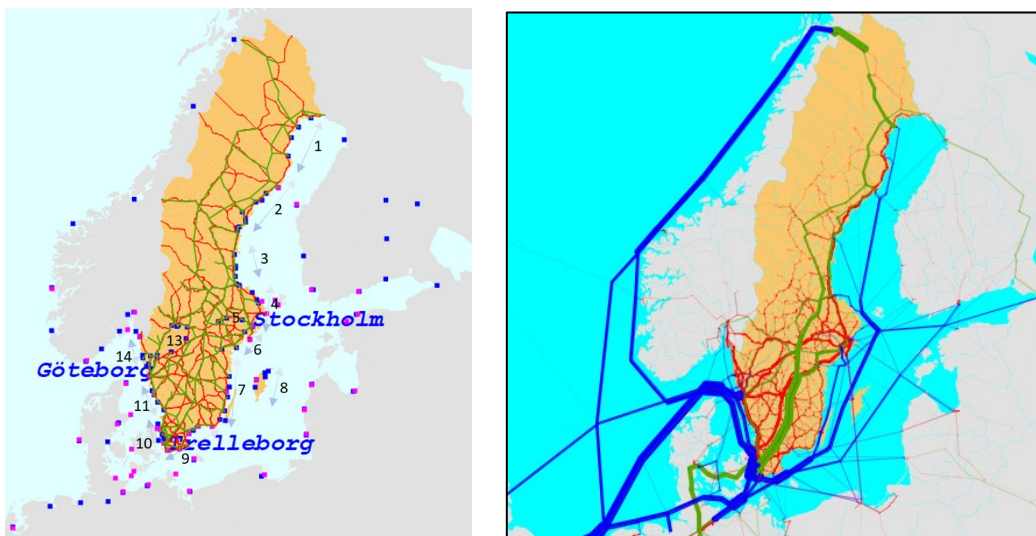


Figure 21 Main land-based infrastructure, and ports at 14 stretches along the coast in Sweden and ports in neighbouring countries (left) and total goods flows in the network (blue=sea, green=rail. Red=road).

The baseline scenario is described in Table 32 where the tonne-kilometres for the different modes and the volume of emissions of CO₂ equivalents, NO_x, SO_x and small particulate matter (PM 2.5) are given. As can clearly be seen the emissions per tonne-kilometre are by far the lowest for rail. This is because the Swedish rail system almost exclusively uses energy from non-fossil-based sources. The amount of emissions of CO₂ equivalents, NO_x, SO_x and PM 2.5 in the different scenarios is calculated both in tonnes and in monetary values. The values are based on the European Handbook on External Costs of Transport (Ricardo, 2014).

Table 32 Tonne-km and emissions to air on Swedish territory in baseline scenario.

	Road	Rail	Sea	Total
Billion tonne-km	53	20	36	109
<i>Emissions to air</i>				
-CO ₂ -equivalents (1000 tonnes)	3,333	29	1,247	4,609
-NO _x (tonnes)	12,621	365	17,972	30,958
-SO _x (tonnes)	8	0	709	718
-PM _{2.5} (tonnes)	207	13	360	581

Sources: Transport Analysis, Statistics Sweden, Swedish Environmental Protection Agency and own assumptions¹⁷

4.2.3 Results

Modal split

The results indicate that the higher fairway dues and pilot fees imply relatively small modal shifts (about 0.3% less sea tonne-km in Sweden) and low own price and cross price elasticities, see Table 33. The same is true for the higher rail track fees (about 1.0% less rail tonne-kms). The impact is, as expected, greater for the introduction of distance-based road user fees (about 4.8% less road tonne-kms).

Beside a shift to more environmental efficient trucks and reduction of road congestion, another purpose of the gate fee instrument developed in WP 5 (see Chapter 3.1) is to encourage transport by rail. For gate fees applied in all Swedish ports, the model calculates an expected increase in tonne-kms on rail. However, the model also predicts an increase on road. This effect can be explained by a shift from combined sea/land transports to long-distance road transports. In fact, sea transports are the ones decreasing the most. Thus, the simulations indicate that the intended shift from road to rail for transports to the ports is outweighed by a stronger shift from sea to road. The results are expected as the gate fees increase the costs for transport chains that comprise road and sea compared to other transport chains.

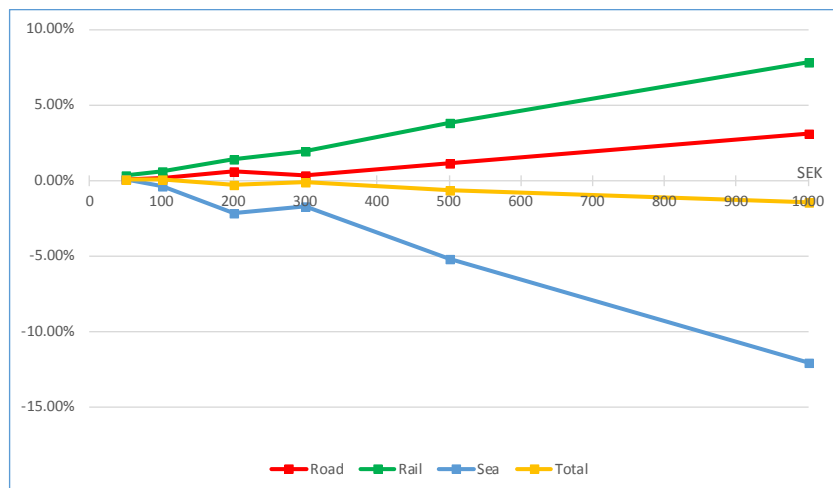
If, instead, gate fees are only introduced in the ports of Gothenburg, Stockholm and Trelleborg the model predicts, as expected, a different outcome. Both rail and sea transports are calculated to increase while road transports decrease. The explanation for this is that competing ports in the neighborhood can be used instead. So, the shift from sea (combined sea/road transport chains) to long-distance road will not occur. In particular, there is a calculated shift from the Port of Gothenburg to the inland sea port of Karlstad, a shift implying a 200 km longer sailed distance in Swedish waters.

¹⁷ PM 10 caused by wear and tear (trucks' tires) are not included in this study.

Table 33 Calculated impact of policy instruments on tonne-km in Sweden (compared to baseline).

Policy instrument(s)	Road	Rail	Sea	Total
1) Higher fairway dues and pilot fees	0.1%	0.1%	-0.3%	0.0%
2) Higher rail track fees	-0.1%	-0.8%	1.1%	0.2%
3) Kilometre-based road user fees	-4.7%	4.4%	2.8%	0.2%
1) + 2) + 3)	-4.6%	3.3%	3.6%	-0.1%
4a) Gate fee of 200 SEK/truck in all Swedish ports	0.6%	1.4%	-2.2%	-0.3%
4b) Gate fee of 500 SEK/truck in all Swedish ports	1.2%	3.8%	-5.2%	-0.6%
5) Gate fee of 200 SEK/truck in ports of Gothenburg, Stockholm and Trelleborg	-0.3%	0.8%	0.7%	0.3%
1) + 2) + 3) + 4a)	-4.1%	3.9%	1.1%	-0.7%

Looking in more detail into the case where gate fees are applied to all ports, the overall tendency is that the modelled effects seem to vary linearly with the gate fee levels, although there are some irregularities at 300 SEK. See Figure 22.


Figure 22 Calculated impact on tonne-km in Sweden for different levels of gate fee per truck (per mode and total).

Although the results are somewhat unstable, the overall tendency is that the increase in tonne-km is larger for the heavier trucks than for lighter trucks. There are two natural explanations for this. Firstly, since the gate fee is the same for all trucks regardless of size, the fee gives incentives to use heavier trucks. Secondly, the above-mentioned shift from sea transports (combined sea/road transports) to long-distance road transports will be dominated by heavy trucks.

Throughput in ports

Gate fees of 200 SEK per truck applied in all Swedish ports are calculated to reduce the throughput overall across all ports by about 2%. The reduction¹⁸ in throughput is calculated to be greatest for Food and Agricultural products, Chemical products and Industrial products (see Table 34).

¹⁸ The unexpected increase for Crude oil is an unrealistic effect of the calibration of the model combined with the fact that Crude oil is a commodity group having very few relations in the PC matrix.

Table 34 Calculated impact of gate fees of 200 SEK per truck in all Swedish ports on throughput (in tonnes) in Swedish ports by STAN- commodity*.

STAN-commodity	Agriculture	Timber	Wood prod.	Food	Crude oil	Oil prod.	Iron ore	Metal prod	Paper, pulp	Sand etc	Chemicals	Industry prod	Total
Baseline (MTon)	6.5	5.9	10.4	7.5	23.9	29.1	5.0	8.9	13.2	13.2	10.8	13.5	148
Change in %	-6.5	-0.7	-3.4	-8.9	0.8	-2.2	-0.3	-2.1	-1.3	-1.8	-2.7	-3.2	-2.3

* STAN-commodities are aggregated from NSTR-commodities.

Looking at the differential effect across different coastal stretches, throughput is calculated to decrease in most stretches with a few exceptions, most notably Gothenburg, which is likely to be due to the relatively high rail share of inland transport at the Port of Gothenburg. Similarly, there is a small increase in the absolute throughput volume of the ports in Lake Vänern, which is likely to be closely related to what happens in the Port of Gothenburg. As might be anticipated, the imposition of gate fees of 200 SEK per truck only in the ports of Gothenburg, Trelleborg and Stockholm is calculated to lead to cargoes transferring from these ports to neighbouring alternative ports, see Figure 23.

A decrease of around 10% is calculated for the combined throughput of the ports of Gothenburg, Trelleborg and Stockholm under this scenario. The application of road user fees is calculated to imply about 2% higher throughput across all ports and a general shift of throughput from ports on the South coast to ports on the West and East coasts.

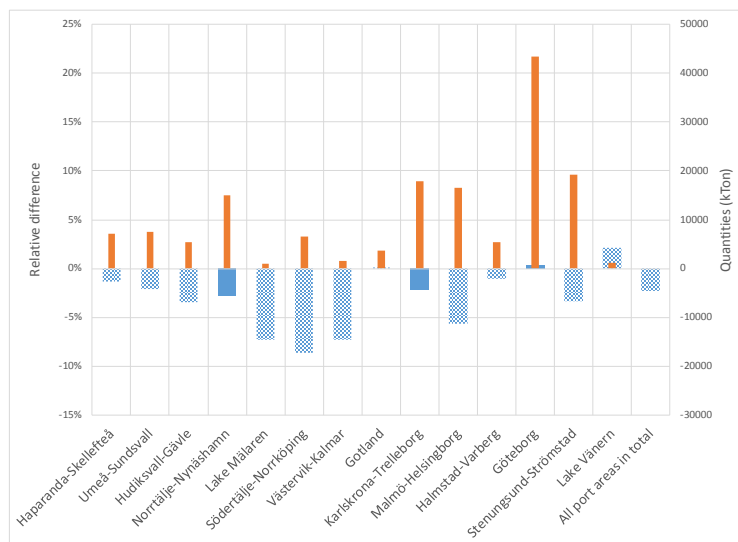


Figure 23 Calculated impact of gate fee of 200 SEK/truck in all Swedish ports on ports' throughput. Blue bars denote relative changes, orange bars absolute quantities in the baseline scenario.

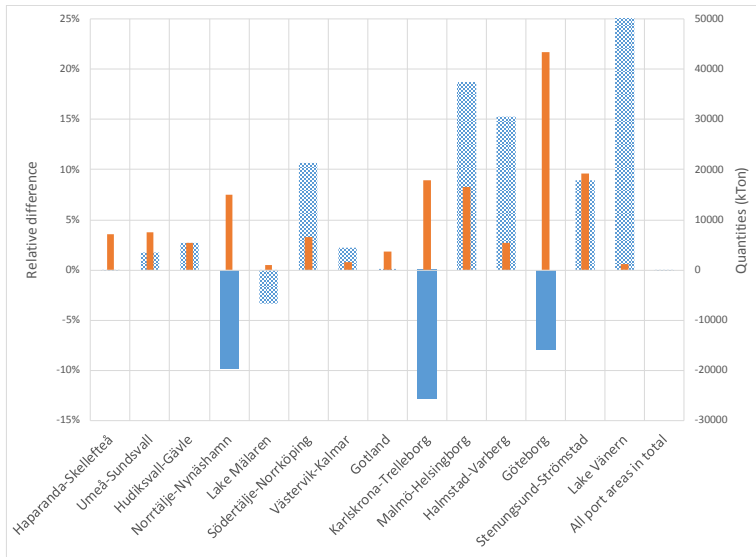


Figure 24 Calculated impact of gate fee of 200 SEK/truck in ports of Gothenburg, Trelleborg and Stockholm on ports' throughput.

A further effect when gate fees are applied to all ports in Sweden is a shift from ports in Sweden into ports in the neighbouring countries. Figure 25 shows, in particular, that there is a shift to the port of Oslo in Norway. The increase in shift to Oslo port is dominated by the commodity groups Food, Chemicals and Paper and pulp. It is obvious that the modes are not only competing but are also complementary to each other.

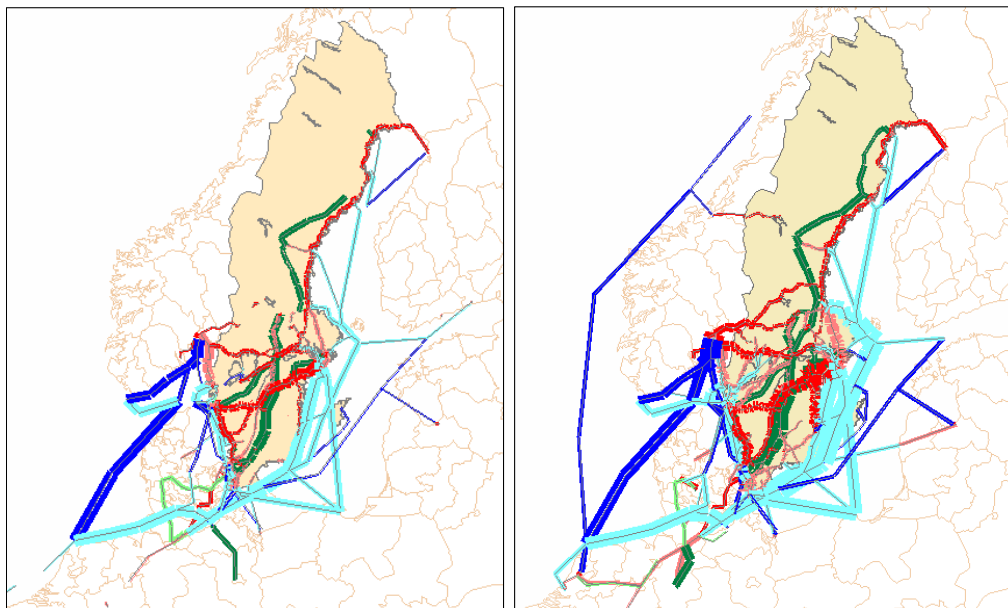


Figure 25 Calculated impact of gate fee of 200 SEK/truck (left) and 500 SEK/truck (right) in all Swedish ports compared to baseline (tonnes). (Red colour: road, green colour: rail, blue colour: sea. Dark colours: Increase; and light colours: decreases)

Emissions

Table 35 reveals the calculated impact on the volume of CO₂-equivalents, NO_x, SO_x and PM 2,5 in tonnes and in value. The introduction of the kilometre-based road user fee is calculated to have by far the largest individual impact on reducing the external costs of emissions. The impact increases

slightly when the km-fee is combined with higher fees for sea and rail transport and/or gate fees for trucks implemented across all Swedish ports. Higher rail track fees and gate fees in the ports of Gothenburg, Trelleborg and Stockholm alone are calculated to lead to slightly increased costs of emissions. The imposition of gate fees across all Swedish ports is calculated to lead to small reductions in the tonne-kms carried by sea (see Table 33) and the overall port throughput in Sweden (see Figure 23 and Figure 24) This is associated with a reduction of the emissions. However, emissions have been calculated using mode specific and not vehicle- and vessel type specific emission factors.

Table 35 Calculated impact on emissions (compared to baseline).

Policy instrument(s)	CO ₂ -equivalents (1000 tonnes)	NO _x (tonnes)	SO _x (tonnes)	PM 2,5 (tonnes)	Costs caused by emissions (million SEK)	Logistics costs (million SEK)
1) Higher fairway dues and pilot fees	0	-41	-2	-1	-2	6
2) Higher rail track fees	10	182	8	4	18	30
3) Kilometre-based road user fees	-120	-74	20	1	-117	908
1) + 2) + 3)	-108	79	25	4	-97	984
4a) Gate fee of 200 SEK/truck in all Swedish ports	-7	-315	-16	-7	-22	104
4b) Gate fee of 500 SEK/truck in all Swedish ports	-24	-769	-39	-16	-60	204
5) Gate fee of 200 SEK/truck in ports of Gothenburg, Stockholm and Trelleborg	-1	91	5	2	4	55
1) + 2) + 3) + 4a)	-122	-306	8	-40	-129	1 072

A further question that needs to be answered is how the infrastructure fees and taxes, that are either revised or implemented in order to reduce emissions, influence the logistics costs of firms. According to our simulations, the increase in the logistics costs of firms in Sweden is somewhere in the range of 3 to 10 times higher than the estimated beneficial value of reduced emissions. However, it is important that other benefits to society, such as reduced costs for wear and tear, congestion, accidents and noise, are also fully considered in order to gain a truly comprehensive evaluation of, and holistic perspective on, the policy measures tested herein. This underlines the need to stress that the specific results derived from the simulations conducted within this paper need to be treated with some caution.

4.2.4 Implications

Methods which attempt to evaluate alternative approaches to the internalization of the external costs caused by transport need to be further developed. In particular, they need to encompass a more holistic perspective on 'benefits to society', other than merely reductions in emissions. Ideally emissions should be calculated using vehicle- and vessel type specific emission factors. In order to facilitate international acceptance and adoption, such methods require agreements to be reached on common definitions and routines. One important and constantly recurring issue relates to setting the geographic demarcations for assessing the impact of the external costs. Another aspect is that the

internalization of external costs is typically limited to the “links” in the infrastructure network. This analysis has shown that there is a need to also include the costs incurred in the ports (and in other “nodes”), especially where goods are transferred between the modes.

The results of this analysis are beneficial as a basis for policy making, i.e. by answering the question as to how much emissions from long-distance freight transport can be reduced under each of the policy measures proposed. They illustrate (i) to what extent national infrastructure fees and taxes one by one and in combination can reduce emissions in the whole transport system, (ii) to what extent different national infrastructure fees and taxes reinforce each other and (iii) to what extent fees, at the local, national and international level, should be co-ordinated. The outcomes are relevant to national and international policy-makers and authorities, as well as port authorities, shippers and transport companies who need to determine unilateral strategies on how to reduce emissions, without undermining their wider business objectives.

5. Systematization and classification of port fees and its compatibility with national, regional and international regulations

5.1 Introduction

Authors: Pernilla Rendahl and Ann-Sophie Sallander, Law department, School of Business, Economics and Law, Gothenburg University

5.1.1 Work package 3: A study in three steps

The overall purpose of this project is to study how differentiated environmental fees and incentives in ports can reduce the environmental impact in ports. Based on the overall purpose, the purpose of Work package 3 is to systematize norms that are decisive for the classification of port- and entry fees on the landside. The work also includes a study of ownership structures in the main Swedish ports. WP 3 thereby consists of three steps and is led by the Law department at the School of Business, Economics and Law at Gothenburg University.

The aim of *Step 1* is to increase the knowledge regarding the theoretical framework for port- and entry fees, thus the rules that decide if such fees can be classified as fees, taxes or custom duties. Step 1 has committed to deliver one peer reviewed article in an international scientific journal and one peer reviewed article in a Swedish scientific journal. Pernilla Rendahl has analysed the EU law perspective which is presented in the article: *The Scope for Member States to introduce Taxes, Charges and Fees on Harmful Substances: A Swedish Perspective* (preliminary title). The article is currently under review by *European Law Review*. Ann-Sophie Sallander has written about the national constitutional perspective which is presented in the article: *Normgivningsfrågor och gränsdragningsproblematik rörande skatter och avgifter*. The article is reviewed and published in *Förvaltningsrättslig tidskrift*, FT 2018/4 p. 747-787.¹⁹ The results of Step 1 are therefore presented in these two articles.

The main results from the two articles concern the prohibition of discriminatory unilateral measures at Member State level, irrespective of what that measure is called (i.e. fee, charge or tax). From an EU perspective it is important to identify a few key issues, such as if it is the external or internal dimension of the functioning of the internal market that is discussed, i.e. if the crossing of a border is between EU Member States or non-EU territories. The room for the Member States to introduce unilateral measures as discussed in this project is both directly and indirectly limited depending on

¹⁹ www.forvaltningsrattslig.org

if it is the external or internal dimension that is at stake. In both situations there is, however, a strong emphasis on the non-discriminatory effects of such measures. National measures are not allowed to hinder (potentially or actually) the free movement of goods or services and it does not matter if it is a public or private actor that charges the monetary remuneration. Permissible charges are those that are linked to enforcement of EU law, with a clear connection between the charge and the service received, thereby a proportionality test need to be carried out when analysing the potential discriminatory effects.

From a national constitutional perspective, first it must be determined whether the monetary remuneration constitutes a tax or a fee. The classification is connected to the question of who has the power and authority to issue binding regulations regarding taxes and fees. The consent of the Parliament is needed when it comes to taxes, but the regulatory power concerning fees can be delegated to the Government, authorities and municipalities. It is therefore necessary to determine the character of the monetary remuneration. Is it a tax or a fee? But also, if it is considered as a fee, is it a burdensome or a voluntary fee? This includes classification and definition possibilities as well as an identification of necessary criteria that need to be considered to be able to determine the difference between taxes and fees, and also between different kinds of fees. In the study, such criteria are identified by studying legislation, preparatory works, court cases and doctrine. For example, taxes are considered as compulsory and do not offer a concrete and direct counter-performance to the payer, while fees are usually more or less voluntary and gives a specific counter-performance from the state to the individual. Regarding the criteria that distinguish between burdensome and voluntary fees, it can be mentioned for example that the burdensome charges usually entail obligations for individuals and constitute an interference with the individual's financial circumstances. On the other hand, voluntary fees are rather just voluntary payments and where the individual has an actual choice. However, it is important to make a comprehensive overall assessment of all conditions to get a clearer picture of the questions.

The aim of *Step 2* is to increase the knowledge regarding already existing port- and entry fees on the landside, both at the national and the EU level. This also includes a study of the ownership structure in selected Swedish ports. Lars-Göran Malmberg has worked with Step 2. The outcome of this research will be published in a book edited by professor Proshanto Mukherjee titled *Maritime Law in Motion* at Spring Verlag in 2019.

Step 3 comprise the most relevant regulatory problems connected to two specific fee proposals delivered by the other work packages in the project. During the project four different proposals of actions have been suggested. These proposals are: congestion gate fees for trucks, environmental fees for trucks, discount when reduced speed and NOx-discount, see further Chapter 3. The first two proposals are connected to the landside and are therefore included in the purpose of Work package 3. The remaining proposals and particularly those focusing on the seaside are thus, delimited from the scope of WP 3.

5.1.2 Methodological comments

Legal research is generally based on doctrinal research which includes identifying and studying applicable legal sources in a specific hierarchical order. The first step of WP 3 is based on such research methods; identifying and systematizing relevant legal sources at both EU and national level. The second step of WP 3 also includes informal interviews with the ports carried out by Lars-Göran Malmberg. The third step of WP 3 filters the suggestions provided by other working packages of the Vinnova-project, that still are within the aim of the third working package, through the findings of step 1. Hence, the main parts of the study, particularly underlying two of the three expected peer

reviewed articles are based on traditional legal research, analysing relevant legal sources and applying them to a specific research question.

5.1.3 Outline chapter 5

Concerning Step 3, both of the proposals for the landside include fees for entering ports, which are suggested to be collected by the port operator. The congestion gate fee for trucks is justified by the congestion when entering ports (see proposal 1 below) and the environmental gate fee for trucks are justified by environmental aspects (see proposal 2 below). Proposal 1 and 2²⁰ are commented by Rendahl and Sallander in Chapter 5.2 based on the results produced in Step 1, which were presented for the rest of the project group and the reference group in February 1st, 2018. Also, some additional comments are made in an attempt to specify potential legal difficulties with the suggested fees, see Chapter 5.2.3.

Step 2 of WP 3 is presented in section 6.3 by Lars-Göran Malmberg.

5.2 Step 3: Comments and recommendations concerning proposed truck fees

Authors: Pernilla Rendahl and Ann-Sophie Sallander, Law department, School of Business, Economics and Law, Gothenburg University

This chapter consists of Step 3, with the aim to give comments and recommendations for two proposed truck fees given in Work package 5 and described in Chapter 3.1. These comments and recommendations are based on the findings in Step 1.

5.2.1 Proposal 1: Congestion gate fee for trucks

The Congestion gate fee for trucks was proposed in Work package 5, and defined as follow²¹:

Model: The proposal consists of a congestion fee for trucks charged when entering the port terminal according to the following criterion:

- All trucks carrying containers and that enter through the gate to the port during rush-hours/peaks have to pay a fee of 200 SEK/entry.
- Rush-hours/peaks are defined as times when there is a high strain on the road network in the surrounding urban area or a high demand for entry into the port. A fee will be charged at: weekdays at 6:30-9:00 pm and at 2:00-6:00 am. The fee is similar to the congestion tax in Stockholm and Gothenburg, but with an earlier start in the afternoon from 2.00 pm to tackle queue issues that usually arise at the port gate after this time.
- The fee is introduced in all Swedish ports with container traffic.

²⁰ See further Chapter 3.1.5 Possible regulation structures.

²¹ The text is written by Sebastian Bäckström and Linda Styhre, and here translated by Pernilla Rendahl and Ann-Sophie Sallander

- The size of the fee is the same for all vehicles regardless of age, environmental class, size or load capacity.

Purpose: The purpose is to reduce congestion and increase accessibility by limiting the number of trucks passing through the urban area and the port during rush hours/peaks.

Who charges the fee: The terminal operator.

Who pays the fee: The fee is paid by drivers directly at the gate to the port, either in cash or by card (similar to existing systems for infrastructure fees in Europe, such as bridge- and road fees).

Who administer/takes care of the money: The money is paid to a fund from which the money is distributed to measures for improving the environment, for example investment in noise barriers, to build railway infrastructure, alternative fuel / energy carriers, power stations; innovations projects to reduce truck traffic problems through the city, etc. The money is managed by a national foundation that is separated from the municipality and the port. The important thing is that the port authority or the terminal operator does not possess the money. The money is supposed to be used for effective measures to reduce traffic distortions of the freight traffic through the city, for example by reduced noise, reduced contribution to air pollutions, reduced climate impacts, increased road safety, reduced dependence of imported energy carriers.

5.2.2 Proposal 2: Environmental gate fee for trucks

The Environmental gate fee for trucks was proposed in Work package 5, and defined as follow²²:

Model: The proposal consists of an entry fee for trucks charged when entering the port, but with a differentiation depending on environmental performance:

- Trucks that enter through the gate to the port have to pay a fee of 200 SEK/entry. The fee is charged irrespective of the size of the vehicle, the amount of load carried or time for entering the port.
- Diesel-powered trucks with engines of Euro class 6 will be given a discount of 50% and pays a fee of 100 SEK/entry.
- Electric/hybrid vehicles and gas vehicles (CNG/LNG/Dual Fuel) are fully exempted from charges.
- The fee is introduced in all Swedish ports with container- and RoRo traffic.

Purpose: The purpose is to achieve an environmental improvement by measures favoring trucks with high environmental performance, thereby lowering local emissions of pollutants such as nitrogen oxides (NO_x), Hydro carbons (HC) and particles (PM).

Who charges the fee: The terminal operator.

Who pays the fee: The fee is paid by drivers directly at the gate to the port, either in cash or by card (similar to existing systems for infrastructure fees in Europe, such as bridge- and road fees).

Who manages/takes care of the money: The money is paid to a fund from which the money is distributed to actions for improving the environment, for example investment in noise barriers, to

²² The text is written by Sebastian Bäckström and Linda Styhre, and here translated by Pernilla Rendahl and Ann-Sophie Sallander.

build railway infrastructure, alternative fuel / energy carriers, power stations; innovations projects to reduce truck traffic problems through the city, etc. The money is managed by a national foundation that is separated from the municipality and the port. The important thing is that the port authority or the terminal operator do not possess the money. The money is supposed to be used for effective measures to reduce traffic distortions of the freight traffic through the city, for example by reduced noise, reduced contribution to air pollutions, reduced climate impacts, increased road safety, reduced dependence of imported energy carriers.

5.2.3 Identification of the most relevant legal difficulties

The essential difficulty: deciding if suggestion 1 and 2 constitutes a tax, fee or even a duty

When deciding if the suggested fees, legally are classified as a tax, fee, a duty or charges having equivalent effect, both national and EU legislative sources need to be assessed. This is due to the difference in competence in the different legal areas. One common denominator is that the actual name of the monetary remunerations does not affect its legal classification. Hence a charge or fee can from a legal perspective constitute a tax. Depending on which type of fiscal measure the monetary remuneration constitutes (from a legal perspective); different actors have the constitutional right to introduce such fiscal measures. For example, if the fee in fact constitutes a tax, it is only the Swedish Parliament that has the right to introduce taxes. If the fee constitutes an excise duty in the form of a toll, it is only the EU legislator that has the right to introduce such measures. Charges having equivalent effect to a toll are forbidden by the EU Treaty.

From an EU perspective, the main criterion is that the fee or tax cannot have discriminatory effects or hinder the free movement of goods or services. Discriminatory fees or taxes are forbidden even if introduced in a manner in accordance with national law. There are also different rules depending on if the charge is effectuated as goods are imported or exported. The suggested charges primarily seem to focus on exports but could equally affect import if the charge is effectuated as goods are transferred onto trucks and then leaving the port (hence, have to pay for leaving the port and not only entering). There is a clear risk that the suggested monetary remunerations can constitute charges having equivalent effect, thus not compatible with the EU Treaty.

From a national perspective, the assessment of whether the proposed monetary remuneration is regarded as a tax or a fee, effectuates several different legal criteria. A monetary remuneration can be regarded as a tax if it for example is mandatory, lack specific and direct reciprocal performance, has a controlling purpose and involves actual re-financing. A monetary remuneration can instead be regarded as a fee if it is paid on a voluntary basis, is reciprocal to a direct and specific counter-performance and represents an actual cost-cutting for public spending. As the suggested charges are described above, they appear to be taxes instead of fees.

Additional issues: What main problems do the classification of the proposed fees lead to?

There are different levels of harmonization in the field of transport and taxation at EU level. Customs duties are fully regulated at EU level, while internal taxes and excise duties are partially regulated by directives (the value added tax is the most harmonized indirect tax but is not relevant for the purpose of this study as long as the suggested measure does not fulfil the basic characteristics of a value added tax). As far as taxes and excise duties are concerned, it is primarily the Treaty provisions

that determine the national scope of legislative power at Member State level. The area of transportation is significantly more harmonized in comparison to taxation, since that area has progressed further at EU level. Therefore, the overall national legislative scope needs to be further investigated depending on the final design of the proposals.

The national assessment of whether the proposed monetary remunerations can be regarded as taxes or fees is decisive for who has the possibility to issue regulations regarding such "fees". Taxes must be decided by the Parliament, while there are some possibilities to delegate powers regarding fees. The independence of the municipal can also give rise to a municipal decision on fees to a certain extent. However, this has to be investigated more closely in relation to the ownership structure that the ports actually have. Is it for example the municipality that owns the port? Or is it a privately-owned port? Or are there other types of owner constellations such as co-ownership? Are there international interests? This has consequences for the continued assessment.

Other problems to consider

Even if it is not a particular part of the purpose of WP 3 for this Vinnova-project we can also foresee a difficulty with the Proposal 1 and 2 related to the administration of the fees. There are several related issues to this. Although the port operator is required to charge the fees; can the operator really be obliged to hand over the collected fees to a specific fund or foundation? Is it the entire fee that is to be transferred to the fund or can something be used by the port operator for example cost coverage? If, in fact, the fees are considered as taxes; can these be transferred to a fund? How would a foundation managing such a fund be assembled? How can the foundation be required to decide on measures such as reducing noise, reducing climate impact or increasing road safety, when a foundation is strictly based on its own charter? How is such a foundation's commitment linked to the responsibility of the municipality for local traffic?

Another difficulty, which is also not covered by the current project, is any competitive distortions that may arise from the collection of fees, as they are based on an incentive structure. For example, charges may affect competition between ports, between local and regional traders and between the different modes of transport. In case of competition, state aid issues are also relevant to consider, which are regulated at EU level.

Follow-up issues: What main problems do the classification of the proposed fees lead to?

There is a discrepancy between harmonization in the field of transport and the field of taxation in relation to EU legal regulation. Customs duties are fully regulated at EU level, while taxes and excise duties are minimally regulated by directives. As far as taxes and excise duties are concerned, it is primarily the EU Treaty provisions that determine the national area of discretion. The area of transport is significantly more harmonized in comparison with taxes, as harmonization work has come much further at EU level. Therefore, the overall national area of discretion needs to be further investigated depending on the design of the proposals.

The national assessment of whether the proposed remunerations are to be regarded as taxes or fees will also be decisive for who has the possibility to make regulations regarding such "fees". Taxes must be decided by the Parliament, while there is the possibility of delegation regarding fees. The independence of the municipality can also give rise to municipal decisions on fees to a certain extent. However, this has to be investigated more closely in relation to the ownership structure that the ports actually have. Is it for example the municipality that owns the port? Or is it a privately-owned port? Or are there other types of owner constellations such as co-ownership? Are there international interests? This has consequences for the continued assessment.

5.2.4 Recommendations concerning gate fees for trucks based on the results from Step 1

A general problem is which regulatory level the environmentally differentiated fees should be introduced at, i.e. if the fees are to be imposed at local, regional, national or EU level. One suggestion is to closely follow the ongoing EU work at the Commission regarding possible harmonization of environmentally differentiated port dues (see: *European Commission, 2017, Study on differentiated port infrastructure charges to promote environmentally friendly maritime transport activities and sustainable transportation*). From a regulatory perspective, a common EU-wide initiative is preferable.

Even when introduced at EU level, questions about how fees are collected and by whom, and the purpose for which they are to be used, may still be affected by Swedish national constitutional legislation. The constitutional legal framework must therefore be considered before a possible implementation of the suggested fees. Another complication that needs to be further examined is the ownership structures of the ports, which also affects the implementation possibilities.

We also recommend continued research regarding the possibility of different incentive structures in relation to differentiated environmental fees. Especially when the incentives include financing of environmental improvement measures through funds, foundations or similar actors. Problems may arise with the duties and powers of the foundations, for example in relations to the local municipal responsibility. In addition, further research is required regarding possible distortions of competition between different actors that may arise due to the model and design of the fees and any discounts and incentives. In addition, incentives, fees and discounts should also be studied on the basis of state aid regulations.

5.3 Step 2: Port ownership – conclusions

Author: Lars-Göran Malmberg, Law department, School of Business, Economics and Law, Gothenburg University

The aim indicated for the third step in WP 3 in the proposal to Vinnova describes as a survey to enhance the understanding of the different and actual port dues in use on a national and an EU-level. This should lead to a better understanding and an enhanced competence in this field of research.

During the deliberations in the outset of the project, the WP 3 decided to work on matters regarding the landside fee structure only. As has been described above in Chapter 5.2 the different suggestions put forward by Work package 5 has generated a number of legal concerns. First issue would be determining the suggested fees as such. Two different fees were suggested and both of them have been discussed above from a legal perspective. The conclusions made were drawn by just looking at them as suggested by WP 5. In both cases there are concerns raised on the suggestions, concerns that they should be determined closer to a tax than a fee. The deliberation made above is clear enough, which makes no need to repeat that in this part.

One issue that needs addressing, concerns the port structure and possibilities to issue a fee for environmental purposes. This regards on one hand the ownership of the port and the operators of the port on the other. This is the crucial issue when it comes to determine the actual possibilities to decide on issuing a fee or not. A survey over the ports in the project (the three in the project group

and the one in the reference group) shows different structures regarding both ownership and port operators, i.e. terminal operators. There are four ports in the project and there are clear differences between all of them. A common denominator is that the ownership of the port rests by the municipality. When it comes to operation of the port, four different facets are here possible to see. There are two extremes Port of Gothenburg on one side and Port of Trelleborg on the other. When it comes to Ports of Stockholm and Port of Karlskrona they are more of a mixed picture.

The city of Gothenburg holds the ownership of Port of Gothenburg through a wholly owned municipal company. The company has its focus clearly set on the parts of the port that operates on a commercial basis only. The Port has rid them self from other entities, either sold or passed over to the municipality. Thereby, there are no fish landing ports, docks for private leisure crafts or the shuttle ferries operated by Västtrafik under the Port of Gothenburg anymore. The port is purely down to commercial vessels only. On the other hand, Port of Gothenburg does not handle the operations from the shoreline and inland. The fees collected by the port are vessel operational fees only. When it comes to terminal activities and fees related to that, the Port Administration leaves that to terminal operators. Although, in the tenancy agreement between terminal operators and Port Administration there is a fee added to the tenancy calculated on the number of cargo entities lifted over the rail. A cost that is, of course, transferred to the shipper or cargo owner from the terminal operator. In the latter relation, this is not to a fee decided by a public authority.

The City of Trelleborg wholly owns Port of Trelleborg and the Port Authority, which is also part of the municipality, operates the port and the terminals. All operations, from entering the port area from land or sea, are a matter for the Trelleborg Port Authority. A very important point to make here is that the port is under reconstruction, where the port is both expanding and moving from the center of the city towards the eastern part of the city. In this movement the roads leading to the port are also under development, shifting them away from the city center to reduce environmental impact.

Ports of Stockholm and Port of Karlskrona are both different from the above-mentioned ports. They both have industrial ports and non- or semi-commercial ports or anchor places. Ports of Stockholm is also spread over more than one municipality. Port of Karlskrona is also a mixed bag with a rather large Ro-Pax terminal, a smaller commercial port (under development to a combi-terminal) and quaysides for passenger vessels in archipelago traffic as docks for pleasure crafts. In Ports of Stockholm the port authorities are in charge for operations in all terminals except the container terminal which is operated by an independent operator under a tenancy such as in Port of Gothenburg. The Ro-Pax terminal in Port of Karlskrona is the dominating activity in the port. Here the ownership of the port has been divided from the rest of the port into a separate company with two shareholders the City of Karlskrona and the ferry operator. The company shares are split by 51% to the ferry operator and 49 % for the City. The majority share to the company obscures the transparency regarding financial activities in the Ro-Pax terminal, a concern for the city members.

Looking at the findings so far: first, in most of the ports the owner is not the same as the operator, secondly, the operator is not a public authority, or entity. This leaves us with the uncertainty whether or not a fee is possible. This leads us further to believe that issuing a congestion gate fee or an environmental gate fee for trucks entering the port area, could pose a problem. From a constitutional point of view issuing a fee could be complicated whether the issuing administration is a public one or not. It is furthermore unclear to what extent such a fee issued by the terminal operator as a mean to control congestion, is accepted at EU-level.

Another issue that in the first glance not seems to be a legal problem, but not said that it could not, relates to the form of traffic generated by the ports. Looking at the four ports there are clear

similarities when it comes to the vessels trafficking the port and the road traffic generated and making their way through the city area. From examining the ports in the project, it is possible to distinguish three types of vessels that generate road traffic. These are RoPax-ferries, RoRo-ferries and container vessels. Other kinds of vessels of importance for the ports are the bulk carrying vessels. In two of the ports, oil, as refined oil or crude, is an important product, so are the cars, as either imported or exported goods. In all but one port, dry bulk as coal, grain or agricultural products is a limited commodity. Port of Trelleborg with its close vicinity to the agricultural areas in the province of Scania is receiving good amounts of seed and fertilizers, but this still generate a limited amount of the traffic the moves through the city of Trelleborg.

The vast majority of transports that poses a problem for the city planners connects to RoRo and RoPax vessels arrival and departure. These vessels are calling port at fixed time slots. Furthermore, their timetables based on a carefully developed logistic timeframe, this done not only regarding port accessibility but also to match peak hours for truck handling. The set timetable dictates when trucks and other vehicles have to be in the port area or when they are leaving it. In the Port of Gothenburg there are at least four different RoPax ferries, which on a daily basis call the port area closest to the city center, some of them arriving and departing several times a day. In the outer areas of the port the RoRo vessels calls port everyday with normally more than two vessels each day, this is also more or less on a timetable basis. Container vessels are also arriving on a time schedule based on the route they regularly take, calling port at the same day, once every or second week. A similar situation is the case also for Stockholm where the port takes on the same kind of traffic as Gothenburg. The majority of vessels arrive on a schedule of a sort. In the Port of Trelleborg and the Port of Karlskrona, the generated traffic comes from RoPax vessels all on a schedule.

So, looking at the above, there is very little room to maneuver to restrict traffic to and from the ports as it is mainly fixed by arriving and departing vessels.

To a large extent this also goes for other European ports. There are although different ways to cope with congestions, even though they are bound by the same type of restrictions as mentioned earlier in this chapter. European Union legislation builds blocks around possibilities to direct traffic through different system of fees. In Chapter 2, written by Gonzalez-Aregall and Bergqvist a number of ports have been examined and the different projects that aim at reducing congestions and emissions. In all of the European ports examined there are no project that regards fees of any kind. In a great number of the European ports there are links to inland water transport to which the ocean ports try to divert the inland transport to from the roads. There is also a more activities to put the cargo on the railways. It has also to be said that ports outside the EU has greater possibilities to use fees as a mean to restrict traffic on specific hours, but this also indicates that those measures do not work with in a European context.

Finally, some personal reflections. First of all is that it is clear the present fees already used by the ports directed to different activities in the four ports in this study are all within the EU framework. Secondly it is this reporter's view that those fees suggested earlier would be difficult to be accepted from both a Swedish legal perspective and an EU-level legal perspective. Furthermore, it would be difficult to see the introduction of such a system from an economic perspective from port operators. The risk that the operator would run is that the cargo would divert to another port and at higher costs. Thirdly, this reporter also believes that there has to be consideration to be made towards other regulations than just port related ones. Some of the more crucial things to look at are rule regarding working hours for truck operations. Any suggestion on controlling time frames for entering and leaving the port has to observe this kind of regulation.

6. Alternative environmental policy measures for city ports' inland transports – an overview

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6.1 Introduction

There are environmental and city development problems related to inland transports to city ports. The heavy road traffic with trucks delivering goods to and from the port area contributes to local environmental air problems and congestion. This project discusses how an economic fee on trucks entering the port area could lead to reductions of CO₂ emissions and other transport related emissions or to reduce congestion in the city road network. It also looks at the possibilities for a fund, in connection with the fees, to grant economic support to investments for environmentally friendly infrastructure, as support for smart logistic. Hence, in this short section we discuss different policy options to implement such fees. Our analysis is based on expert knowledge at IVL Swedish Environmental Research Institute, group of policy and economics. We discuss in short seven different policy measures, listed in Table 36, and make a somewhat longer description of the port environmental permit, as this measure is least covered by other parts of the project.

Table 36 Alternative measures compared as an overview.

	Who decides on tariffs and collects the money?	Does the decision maker have incentive to capture the whole environmental cost?	Will tariffs reflect local disturbances?	Is there a risk for pushing goods to other Swedish ports?	Can the money be returned to port logistics?
National environmental tax	The state	Yes	No	No	No
National environmental fee	The state	Yes	No	No	Yes
Law on land-based port dues	The port	No	Yes	No	Yes
Voluntary fee-system	The port	No	No	No	Yes
Congestion taxes	The state	No	Yes	Yes	No
Fees prescribed in environmental permit	The port	No	Yes	Yes	Yes
State - city environmental agreements	The port/city	No	Yes	Yes	Yes

6.2 Overview of environmental policy measures

There are many different policy measures that may impose economic tariffs on trucks to and from port areas with the aim of reducing social costs of emissions or congestion. First, we discuss four measures that cover all Swedish ports. A national wide coverage may eliminate unfair competition between different Swedish ports, however being more difficult to adjust to local environmental conditions. We therefore also discuss three measures that cover only specific city ports and may well target the local environmental conditions. The disadvantage with measures on specific city ports is rather the risk pushing goods to other ports which disincentives the local port and city authorities.

6.2.1 Measures covering all ports

Environmental tax on trucks entering a port area

A new environmental tax is created to capture the externality of the societal costs of emissions and congestion related to inland transport of the ports. The tax can be imposed on trucks entering port areas (one truck - one fee), in ports obliged to have a permit for the port operation. Since both the cost of emissions and congestion from inland transports are considerable higher for ports located near cities one may want to limit the tax to city ports. There is no established definition of city ports which means such definition then has to be settled. One may also want to differentiate the tax to relate to emission standards of the truck and can then use the Euro-class system to reflect a higher tax for more pollutant trucks. It would be difficult to differentiate the tax in relation to congestion as traffic in the local context differ too much to be reflected in a tax equal to all ports.

Taxes in Sweden can only be decided by Riksdagen, and every little change in the tax also needs decision by Riksdagen. This means the preparation for such tax needs to be really thorough and the acceptance for the tax consistent over a long period of time. Payments of state taxes must go to the state budget and cannot go to a special fund. Since this environmental tax could be regarded as breaking new land in the way it imposes tax on transports at certain locations, a bit similar to the congestion taxes in Stockholm and Gothenburg, it might gather substantial resistance in the public opinion. The tax also needs to consider the EU regulations on ports which is sensitive to constraints of delivering and transports goods to and from the ports, however also in favour of effective environmental measures.

Environmentally differentiated state fee on trucks entering a port area

It might be possible to create a state fee to capture the externality of the societal costs of emissions and congestion related to inland transport of the ports. This would be a similar system to the Swedish fee on NO_x from industrial plants bigger than 25 GWh. This fee was introduced 1992 and does not fulfil the normal criteria of a fee as it does not reflect the payment of any specific service. It has nevertheless been handled as a fee, and not a tax, because it is paid back to the payers based on the amount of energy produced (reduced with the administration costs, often less than 1%). As a fee it can be adjusted with decisions by government which is significantly more flexible than each time go all the way to parliament.

Returning the revenues to the sector at large is probably not enough to regard it as a fee. Notable, the 1984-2009 Swedish tax on nitrogen in fertilizers returned the income to the agriculture sector to research and environmental actions but was still regarded as a tax. If a state fee on trucks entering

port areas is created in the same way as the fee on NO_x it needs to be a more or less automatic system returning the money to the same collective as paid the fees, for example a return based on the amount of goods delivered by the trucks.

In creating the structure of the fee similar difficulties considering differentiation and ability to internalise local environmental costs arise as with the tax alternative above. Also, EU-legislation needs to be taken into account.

Law on land-based port fee

One may think of a national law that prescribes ports themselves to charge trucks entering the port area based on the environmental impacts. Such system would in part copy the port dues for ships which dock the port²³ (however the Swedish regulation for such fee does not include a specific requirement that those fees are differentiated on environmental impact of the ship²⁴). With this measure it is not the state that decides the level of the tariffs but the port operator. The law may prescribe the environmental differentiation to be based on Euro-class system or other transparent system. It may also prescribe if there should be a minimum fee for the trucks with least environmental impact. However, prescriptions of minimum fees might be sensitive in the respect of whether such law at all would be acceptable as the purpose is not to constitute tax legislation.

Since it is the port operator that sets and collects the fees the operator can, if it wishes, easily designate any revenues to port transport logistic systems facilitating further improvements concerning the environmental impacts from inland transports.

Voluntary fee-system set by port operators

One may also think of the introduction of a fee system fully on the initiative of the port operators themselves. The reasons for such initiative can be to prevent the legislator from regulating an issue which would restrict the freedom of the port operators and potentially harm the operations in the ports. The initiative may be part of the strategies of the ports to take social responsibility and benefit their image and value.

Port operators might thus agree to work in a coordinated manner to decrease the environmental impacts of land transports to and from city ports. As part of such initiative there can be common tariffs, environmentally differentiated, on trucks entering port areas. The income from the fee on trucks the port operators can allocate to improvements in port transport logistic systems, either in a fund driven jointly by the port operators or to projects in each port.

6.2.2 Measures on specific city ports

Developed congestion taxes

The existing tax legislation imposing congestion gate fees in the cities of Stockholm and Gothenburg can be developed to target the specific congestion problems of trucks going to and from the port areas in those two respective cities. It might also be used to target the environmental standards of the trucks (Lindblom et al. 2012). However, as it is tax legislation it is inherently hard to change as every little change in tariffs as well as new places for the payment (automatic portals in the road

²³ See PM on changes of the Law 1981:655, which the Ministry for Enterprise and Innovation sent for comments Nov 2017 <https://insynsverige.se/documentHandler.ashx?did=1922153>

²⁴ IVL Swedish Environmental Research Institute PM Statlig styrning av hamnavgifter Sep 2018 suggested the Swedish Environmental Agency to act to include environmental differentiation on those fees.

network which register each number plate) need to go through parliament for a vote and decision. This particular legislation has also been politically dependent on pre-decisions by city council and is therefore even harder to pursue.

Payments of state taxes must go to the state budget and cannot go to a special fund, however the income from congestion fees has been returned for regional infrastructure like motorways and new railroads and subways. How new infrastructure could help to mitigate environmental impacts of inland transports might be set in focus if trucks to the port are specially targeted in a reform of the congestion taxes where an increased income could be returned to the region from the state.

Environmental fees set by the port operator on request - by the port environmental permit

Ports allowing ships over 1 350 GT are obliged to have an environmental operational permit which sets out limits and regulation regarding local environmental impacts (Miljöprövningsförförordningen 24:1). The port operator applies for the permit at the County Board and the decision can be appealed to the environmental court. The operator also has to provide an environmental impact assessment (EIA) for the operations in the port. This assessment needs to describe also inland transports to and from the port area. On the basis of the EIA the permit may prescribe the operator to mitigate harmful impacts on the local environment. As an example, impacts of transports at a distance of 22 km from the port were considered when the environmental permit of the port Kapellskär north of Stockholm was decided by the court, however in that case no mitigating actions were prescribed in the permit (MÖD 2007:55).

The permit cannot prescribe mitigating actions which are impossible for the operator as there is no means in the hand of the operator to fulfil it. It is however possible to prescribe the operator to further investigate tools that in a meaningful way mitigate environmental impacts of the transports connected to the port. If such a tool would be to invoke an environmental fee, or other measure, on trucks entering the port area it could in theory also be included as part of the permit. Economic incentives to make customers to the port to act in an environmentally better way have been discussed in connection to electric charging of ships at berth and the Swedish Maritime Administration has proposed environmentally differentiated tariffs (Södertälje port, MÖD 2005:10). In environmental permits regarding airports measures to motivate transport service to the airport to decrease its environmental impact have been considered and the operator prescribed to develop such tools (see permits for Arlanda and Landvetter airports).

So far there is no Swedish port having a permit where conditions are directed at environmental fees for inland transports. If such conditions could be developed is a question for the regulatory authorities (the County Boards, as well as municipality environmental administration and national environmental agency). Foremost it is a question of whether such fees would be an effective measure to reduce emissions and other disturbances from the inland transport connected to the port.

Environmental fees set by the port operator on request - in an agreement with the state to get infrastructure investments

If the operator of the city port is owned by the city, it might be possible to include issues of port logistics in 'city environmental agreements' which some cities have concluded with the state (Förordning om statligt stöd för hållbara stadsmiljöer 2015:576). Those agreements may for example give state support for the building of a road that allow trucks going to the port without driving through densely areas of the city. In return to such agreement the city must make sure measures are

implemented to mitigate traffic increase. Introducing new tariffs on truck transports might be one option for such return measure in a city environmental agreement.

6.2.3 Short evaluation of the alternatives

The choice of policy instrument depends on which problems one wants to solve or which positive development one calls for. The overview shows that attacking specific local disturbances would need port specific instruments, while impact on the truck fleet serving the Swedish ports would ask for a general instrument. Voluntary systems, initiated by actors in the sector or in agreements with authorities, will on the other hand be the most flexible form to develop systems where logistic effectiveness and higher environmental standards of ports inland transports.

Considering there is no fees on inland transport today in Swedish ports, it is a challenging step to introduce them. Starting such system in one port may imply a risk to customer relations. This risk may be lowered with more research exploring both specific environmental impacts, economic gains in changing the logistics and what kind of income such system could bring for the port. With such information there will be easier for port operators to engage in system development and green profiling, as well for municipalities and environmental authorities to see how issues of their concern can be taken forward.

One way forward in order to make it more attractive for ports to implement fees could be to link a defined system of environmental fees to the right of applying state financed infrastructure such as roads and railways. This could then be a parallel to the so called "statsmiljöavtal" where cities that comply with goals and actions regarding cars and road traffic can apply for state financed infrastructure, i.e. public transport investments. A recommendation is therefore to investigate such a scheme in forthcoming work.

7. Cost-effective instruments and political feasibility

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7.1 The need for policy – why the market fails

In economics, we often assume each consumer or firm chooses actions that are optimal for that actor. In a so called 'perfect' market system, there would be no environmental problems – and no need for environmental policy. In reality there are numerous failures of the market system which include externalities, public goods, poorly defined property rights, noncompetitive markets, increasing returns to scale, and asymmetric information. We need to understand the nature and extent of such imperfections in order to suggest remedies in the form of policy instruments.

Externalities are side effects of production or consumption. The unregulated market oversupplies negative externalities, such as tail pipe emissions from cars, trucks and in fact any mode of transport. Public goods are products or services, including "ecosystem services", enjoyed in common, such as a clean and healthy atmosphere which are not necessarily supplied by the market. Poorly defined property rights also create imperfect conditions. If rights are not well-defined for all possible goods and services, externalities result – as when no one owns space on roads and the result is congestion to the detriment of all. With well-defined property rights (and a few other assumptions like low or zero transaction costs), then in principle external effects would be avoided (Coase, 1960). In analysing environmentally differentiated port dues it is particularly important to distinguish between local externalities and global externalities. In fact, this is not a dichotomy but rather a scale. Some disturbances are extremely "local" such as noise which typically applies mainly to a scale of meters up to kilometers. Truly global are for instance carbon emissions which have exactly the same effect if emitted in Gothenburg or Singapore. Naturally there are several pollutants belonging to an intermediate category of externalities including soot or NO_x and SO_x that have a regional range which again can vary from the fairly local level of a city up to the level of countries or continents.

A particularly relevant category for us to consider is various kinds of congestion. Congestion is defined as a reciprocal externality imposed by each of the operators, producers or participants on all the others. It arises by virtue of the fact that there are capacity constraints on how many can use the system at the same time. Congestion affects the operation of the activity itself and also tends to worsen other environmental externalities to third parties.

Noncompetitive markets are those in which individual actors such as international companies are large enough to have market power and therefore undue influence on prices and rules in the marketplace. If there are increasing returns to scale or indivisibilities, implying production sets are not smooth or convex, then markets without government intervention are likely to fail to maximize social welfare. Extreme cases are monopolies, whether resulting from scale economies or protection. Typical examples in the transport sector include monopolies or other forms of restricted competition (oligopolies etc.) for rail, taxi or air travel. In the area of shipping it is clear that ports have a special position as hubs in a big interconnected structure.

There are additional types of market failure such as asymmetric information, the lack of equal access to information, and incomplete information. Market failures are one key motivation for environmental policy, but there are others that are also relevant. For example, behavioral biases and anomalies. Behavioral economics helps to explain why individuals do not always simply maximize utility and why individual behavior may be more complex than can be described by economists' simple models, ultimately making it harder to evaluate welfare implications. When people act in groups, they may feel envy, altruism, anger, revenge and many other feelings that can influence behavior. These insights help us understand why, for instance, some people invest in expensive cars (to attain status) when in fact it would be better for their health and economy to go by bike or public transport.

Some claim that the market fails to manage ecosystem resources because of vagaries of human "nature" such as ignorance, greed and procrastination (see e.g. Naess, 1989). These are powerful forces indeed, but the main reasons why we have environmental disasters and overuse our resources are market (and policy) failures as in collective action dilemmas where the incentives for individual action fail to align with societal interests (Ostrom, 1998).

7.2 Policy failures

Where markets fail, policies should be able to rectify or at least dampen the extent of the failure. Yet many times these market failures are instead exacerbated by bad policy. Policy failure is not unique to environmental policy and there is a broad literature in political science concerning policy failure in general; see, for instance, McConnell (2015) or Derwort (2016). Fisheries provide many such examples. The absence of property rights leads to a tragedy of open access, and the situation is often compounded by policy failure. When there is overfishing and fishers are impoverished because of small catches, public policy should reduce fishing effort. Instead, politicians typically hand out subsidies intended to "help" fishers. These handouts may benefit fishers in the short run, but typically exacerbate the depletion of fish stocks, resulting in even higher costs and lower earnings. Also, in the transport area we find that bad policies are used. To deal with congestion the best instruments are some kind of congestion pricing, but these are often resisted and instead politicians favor instruments such as the "dia sin auto" where cars are banned from driving certain days based on their number plates. Time and again it has been shown that such policies are quite ineffective. Sometimes they lead to people buying a second vehicle and driving goes up – while pollution may even go up a lot since the "second" car is often a cheap and old car.

The transport sector is somewhat infamous as an arena for economic agents who want to influence public policy making to their benefit. Oil and automobile companies want to promote cars and thus lobby against good public transport solutions. Companies that provide infrastructure lobby for the building of more bridges, tunnels, roads and railways and so forth.

Unfortunately, market failure is quite often compounded by policy failure. This can happen because many market failures are related to the power and influence of some market agents. These agents will have power and influence not only in the market place but in the policy arena too. The dominance of perverse policies often reflects lobbying forces, characterized by large and powerful agents, and a political economy that systematically promotes them, particularly in the climate area (Berkes, 2006; Hepburn, 2010; Oreskes and Conway, 2010). The coal, oil and gas companies are among the largest and most powerful companies in the World. There are many examples of countries where fossil interests completely dominate the economic policy of a country. This clearly applies to many oil exporting countries for example. More importantly fossil interests clearly have very

aggressive and successful lobby activities that give them considerable power over economic policy also in countries such as the USA.

7.3 The menu of instruments

Having identified some reasons why we need policy instruments, we turn to the menu of policy instruments available. Traditionally, policy making has occurred at the national level simply because this is where the power to implement and enforce exists. A prominent example is a fuel tax or a mileage tax for road vehicles. In the areas of shipping and air freight it is generally a lot less common to have any policy instruments largely due to the fact that these vessels can fuel anywhere and there have been traditions and agreements not to tax their fuel. It is all the more important therefore to consider other possibly instruments and in fact, studying policies in different areas we find that taxes and charges only make up a subset of a broader menu of environmental policy instruments. In choosing a policy instrument we need to consider not only the environmental problem at hand but also the economic and social context and ask ourselves questions such as: is this a market with competition? Is it an area of rapid technological progress? What are the informational requirements? How will the costs of control and enforcement depend on the choice of policy instrument? We will not go into these issues, but the matrix below provides a simple overview of the many different types of policy instrument available.

Table 37 and Table 38 below are attempts at illustrating some of the many dimensions of policy choice. It is not a very satisfactory table since the different policy instruments are not easy to categorize neatly. The table has four columns (– but the rows do not have any particular meaning). Each column represents in some sense a type of policy instrument – but even at this grand level of generality we immediately have problems. We have avoided the term “economic instruments” since economic theory will sometimes lead to the recommendation of for instance zoning or bans or standards - and that is not what people expect when they hear the word “economic” instrument. We have to some extent replaced this with the words like “price-type”. Taxes, subsidies and charges are examples of instruments that directly act like a price and in this sense, they are “economic” or “market-analogous”. But so are tradable permits. What is truly definitive for permits is that they are property and we therefore categorize them in a column for “rights”. The column regulation should be fairly self-explanatory and contains in fact much of what is the bread and butter of ordinary environmental management by Environmental Protection Agencies around the world. The final column we have referred to as legal or informational and it includes both labelling and voluntary agreements, liability rules and so forth. Ideally a perfect table should be like the periodic table in chemistry where every element has not only a column but also a row. By that standard we have failed so far to categorize policy instruments, but we hope the discussion somewhat clarifies the choice all the same.

Table 37 Environmental Policy Instruments Menu.

Price-type	Rights	Regulations	Info/legal
Taxes	Property rights	Technological standard	Public participation
Subsidy	Tradable permits	Performance standard	Information disclosure
Charge, Fee/Tariff	Tradable quotas	Ban	Voluntary agreement
Deposit-refund	Certificate	Permit	Liability
Refunded charge	Common property	Zoning	

Table 38 Environmental Policy Instruments Menu – transport sector.

Price-type	Rights	Regulations	Info/legal
Fuel Taxes	Vehicle licences (auctioned)	Mandatory Catatyser	Public participation in urbanplanning
Subsidised ethanol	Blending mandates	CAFÉ s tandards	Info disclosure on mileage
Parking Fees		Ban on 2 stroke	Voluntary agreement
Depositrefund for old batteries/cars		Permit	Liability
Bonus Malus	Car Pooling	Zoning	

The choice between these instruments depends on a large number of criteria such as their efficiency, flexibility, and the distribution of costs they imply which decides their political feasibility. In order to effectively address environmental problems, it is common that a combination of several different environmental policy instruments needs to be used (Sterner and Coria, 2012).

One simplified way of organizing our menu of traditional policy instruments (adapted from Sterner and Coria, 2012) is in the overarching categories of 1) Price-type; 2) Rights; 3) Quantity Type Regulation; and 4) Informational/Legal. The list below is by no means perfect or definitive. Many instruments can be classified in several ways. For example, tradeable permits could be considered either property rights or quantity type regulation.

7.4 Instruments appropriate for ports

Normally it is a public authority that uses policy instruments to deal with market failures. Among public authorities we can distinguish between public authorities at different geographic and jurisdictional scope. The two main categories are the state and various local authorities such as

counties or municipalities. Also, supranational bodies such as in our case the EU have important pieces of relevant legislation and use policy instruments. There are at least two relevant principles deciding where instruments are used. First of all, the relevant jurisdiction has to have the legal and political authority and the administrative means to implement and enforce the instrument. Secondly there is often some recognition of subsidiarity which a principle is saying that social and political issues should be dealt with at the most local level consistent with their resolution. This means in our case that instruments should be used at a local or national level if the externalities are local/national but, if possible, at higher geographic levels if the externalities are more far-reaching. For global externalities or global public goods, this latter principle would suggest global policy-making. However, if there are no bodies with the political and legal power to make such decisions then national or local bodies might be tempted to use instruments in their place.

7.4.1 Nongovernmental policy making

The ideal case seems simple enough, a global body should take care of climate policy while really local agents such as municipalities should take care of noise and local smog. But the real world is far from ideal: at some levels where policy making is badly needed, there is a lack of legal or political authority and institutions. At other levels the policy makers may fail to fulfill the duty of maximizing welfare. They may for instance be captured by powerful interests. It is commonplace to see that local authorities become defenders of local polluting firms for fear of job loss and for other reasons such as identification.

There are a number of reasons why sometimes private agents might want to pursue an environmental agenda and even use “policy instruments”. Large private companies may have a more sophisticated strategy than simply maximizing short-run profits. They may care about their reputation, they may be run by CEOs who have a personal agenda of being pro-social or they might believe that their long-run profitability hinges on being environmental even at the expense of short run profitability. Another reason may be to pre-empt political regulation. It is quite common for industrial organizations to strive to avoid public use of policy instruments by “voluntary” environmental policy at the company level. All in all, businesses may thus be prepared to sacrifice some short run profits if it helps avoid public regulation, build brand image, attract or keep customers, staff, shareholders and partners in other markets such as the finance market. If a big shipping company or customer decides to pursue a green strategy one option is frequently to control the supply chain of intermediaries, suppliers, partners and so forth. This is a case when a large company might use procurement rules, pricing or other instruments to coerce other companies.

7.4.2 Environmental policy at Port Authorities

When and why should a Port authority levy environmental fees? Since there is quite a lot of fuzzy and wishful thinking about the environment it is important to try to be analytical here. The situation is clearly different for different market failures: for congestion, for local externalities, regional and global externalities. It also depends on whether the port is private or public, whether we are discussing fees or taxes; we need also to refer to the legal preconditions both for EU versus national and National versus local decision making. Finally, considerations are made more complex by the fact that we are studying network activities like transport where there is a whole chain that may be globally has low externalities but locally high ones.

Congestion issues seem to me to present the clearest case for intervention since congestion affects the operational conditions for core business at the port. Just like operas or hotels can charge higher

fees on popular days or the railway can differentiate fees depending on traffic intensity so it would seem that ports could do something similar based on purely business oriented grounds.

When it comes to local pollutants including noise and smell (as well as congestion imposed on other motorists), this would normally be something that should be regulated by local authorities. If the port is somehow public, it would be conceivable that the municipality were to delegate some authority to regulate local nuisance to the port (assuming this is legally permissible). If the municipality does not regulate and does not delegate such authority it might still be the case that the port – for other reasons would try to use its influence to reduce local nuisance. The port might want to do this for the sake of green image, to pre-empt public action or for reasons of image. The port may want to avoid critique and complaints from neighbors and from the local community. The port knows that it is dependent on good will for both daily operation and for permission to expand or modify operations. The port may also want to expand and is in competition with other modes of transport such as long-distance trucking. For such reasons it may want to defend its green image.

When we come to regional and particularly to global emissions, the arguments for policy by a port would appear to be further weakened. Climate policy is best done at the global level or if that is not possible then by nations states acting with as much coordination as possible. However, we can easily see that this is not happening. The world is making very little progress in this important area. Shipping is generally speaking efficient from the viewpoint of climate. However, shipping is at the same time an area that for historical legal reasons has been exempt from a lot of legal regulations and bunker fuels have traditionally not been taxed or regulated. If those who are involved with shipping, including port authorities, want to use a green image as a commercial argument, for example in the competition with air freight or long-distance trucking, they might be to be pro-actively green.

Still one should perhaps be aware that there could be perverse effects if a port were, for example, to penalize local emissions of carbon (from trucks or by requiring ships to slow-steam. If this leads to redirection of traffic to other modes of transport or to other ports, then the overall effects may be to increase global carbon emissions even if a local reduction were to take place in the municipality concerned. This speaks in favour of harmonisation of policies between neighboring ports to avoid local competition leading to a suboptimal reallocation that might in fact involve an increase in overall emissions.

7.5 Comments on the four incentives

Four incentives have been analysed in the project. Two on the seaside, including discount of the port due for ships that **reduce NO_x emissions from auxiliary engines**, and **reduce speed in the fairway channel**, and two incentives on the landside: **congestion gate fees** and **environmental gate fees** for trucks.

All four are mainly related to local problems of congestion or local air quality. It is therefore reasonable that these are regulated locally. If they are not regulated by the municipality it seems reasonable that the Port authority regulates. This can be seen as the port regulating on behalf of the municipality. It can also be seen as image creation, that the port being proactive to avoid conflicts with local residents or other interests that might restrict the port. In a competition, the port may want to brand its activities as environmentally superior. To make this credible a number of instruments such as these four incentives might be very appropriate. Table 39 shows the polluters these measures are targeting, and the goal and policy related to them.

Table 39 Goal and policies for the four incentives.

Policy Suggested	Polluter	Goal	Policy	Whose responsibility/ Use of funds
Discount for ships with low NO_x emissions	Ships (excluding Roro-ships and ferries)	NO _x in port	Discounted port dues for low NO _x engines	Port
Discount for ships that reduce speed in fairway	Ships (Roro-ships, ferries and container ships)	NO _x in regional vicinity, CO ₂	Discounted port dues for slow steaming	Port
Congestion fees for trucks	Vehicles	Congestion (and local pollution)	Extra fee to port for rush hours	Port/Local Fund for environmental investments e.g. noise barriers
Environmental gate fees for trucks	Vehicles	NO _x , HC, PM etc in local road traffic	Entry fee to port. Euro class 6 and electric exempt	

One problem might be that one does not want to induce substitution to another port. This is solved by suggesting same instrument for all Swedish ports. The instruments do not consider the risk of moving to non-Swedish ports.

Another problem, discussed in Chapter 5 and Chapter 6 of this report, might be the right to charge taxes – which the port does not have – or fees, which it probably does have for reasonable purposes. This may well be connected to how the fee proceeds are used. Environmentally differentiated rebates for ships are already in use, but the introduction of fees is more complicated. Creating a fund and using the fees for local investment may help. Particularly if the local investments are closely tied to reducing the relevant nuisance.

8. Conclusions

This last chapter summarises the project and gives examples of future research related to the work carried out in the different work packages.

8.1 Concluding remarks

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In this project we have investigated environmentally differentiated port dues from an interdisciplinary approach, including studies on environmental, legal, policy and market-related aspects, as well as consequences for goods flows and ports' competitiveness. Because of the transport sector's large share of total greenhouse gas emissions, accounting for more than one quarter in the EU, and a poor record in reducing these emissions in recent years, the sector needs to decarbonize to a very high degree within a few years. Further, emissions with more local and regional effects, noise, and congestion caused by transports need to be reduced. To accomplish rapid changes, many actors including ports, need to cooperate and contribute. Environmentally differentiated port dues can be one solution, among others, to promote a shift to more environmentally efficient transport, vehicles, ships, technologies and alternative fuels.

In general, inland transport has traditionally not been a responsibility of the port. However, larger environmental and city development problems related to road transports have resulted in increased pressure on ports to suggest and implement mitigating actions to reduce environmental impacts caused by road traffic to and from the port. These requirements may well be more tightened in forthcoming years, especially for municipally-owned ports.

Before introducing fees on trucks on a larger scale, the risk of sub-optimization needs to be carefully analysed. Redirection of cargo from energy-efficient shipping to long-distance road transport and moving cargo to neighbouring ports can lead to an increase in overall emissions, to give two examples. This speaks in favour of harmonisation of policies between ports, to avoid local or regional competition. The port charges expected beneficial effects on society, such as less congestion, accidents, emissions and noise, needs to be comprehensive evaluated before implementation.

There are currently many incentive schemes active that offers lower port dues for ships. There are examples of ports that differentiate dues based on either complete indices or one or a couple of indicators. Other ports have a more direct approach and use e.g. NO_x-reduction measures on board ships to differentiate, or speed reduction for ships in the fairway channel. Approximately 20 Swedish ports are using environmentally differentiated port dues for ships, and many ports have used incentives for NO_x reduction since the 90s. The widespread use of environmentally differentiated port dues for ships in Sweden indicates that, on the seaside, this is not a controversial issue. For land transport, the situation is somewhat different, and there are currently no environmentally differentiated port dues in Swedish ports. However, the international mapping of port initiatives to reduce the environmental impact identified 76 cases and 165 incentives for inland transport. The most common objectives are modal shift incentives through a dedicated infrastructure, reduction of air emissions from engines, as well as monitoring programs and reduction of land congestion applying technology services.

Four incentives were analysed in detailed in this project. The result shows that ports with the investigated rebates for the seaside, i.e. discount of the port due for ships that **slow down in the fairway channel**, and **reduce NO_x emissions from auxiliary engines**, potentially could reduce the CO₂ and NO_x emissions with up to 3% with a rather modest compliance level. Slow steaming when approaching and leaving the port has also proved to be an efficient measure with very high level of compliance (between 90-95%) in Port of Long Beach in California.

For the landside, two incentives were analysed. First, **Congestion gate fees for trucks** in the container terminals where all trucks that enter through the gate to the port during rush-hours must pay a fee of 200 SEK/entry. Second, **Environmental gate fees for trucks** in ports with container and RoRo-traffic where trucks that enter through the gate to the port must pay a fee of 200 SEK/entry. Assumptions included that diesel-powered trucks with engines of Euro class 6 would be given a discount of 50%, and electric/hybrid vehicles and gas vehicles (CNG/LNG/Dual Fuel) were fully exempted from charges.

It turned out to be difficult to calculate the environmental impact of suggested truck fees, mainly because the state of knowledge of how road transports are carried out to/from ports is inadequate. This includes a lack of information of charging/discharging points, the number of traffic movements, the route through the urban area, the time of the transport, the truck's environmental class, the load capacity and the amount of cargo loaded. Observations at the port gates were carried out in the container terminals in Stockholm and Gothenburg to collect data on size of the trucks, Euro class and number of containers loaded. This investigation has shown that the road-based container transports to and from the ports seem to operate under non-optimal conditions. Many trucks arrive to or leaves the terminal with no load, the majority of the trucks only loads 2 TEUs (while 3 TEU trucks are allowed) and 10-25% of the trucks are using outdated high polluting engines (Euro class 2 or 3). Thus, truck traffic through the densely populated areas of the port cities cause unnecessary disturbances in the form of congestion, noise and air pollution. Even if the old trucks make up a small proportion, they account for most of the emissions of particles and nitrogen oxides (NO_x).

The theoretical traffic reduction potential from the two observations in port terminals was found to be between 30-50% by using better utilised newer and larger trucks. One reason why these potentials are not realised today lies outside the influence of the port and the road haulier. This is related to stringent pick-up and delivery time windows, terminal opening hours, locations of destinations, queuing and waiting times and limits set by drivers' schedules. Consequently, the suggested fee structures of 200 SEK per truck were by expert groups and road hauliers assessed to not be very effective, mostly based on the observation that the transport is a relatively small cost in comparison with costs and risks related to reorganising logistics operations. However, the judgements regarding the potentials for port gate fees made by experts and hauliers need to be further challenged. Further, a fee structure could be used effectively to ban the trucks operating with Euro class 2 and 3 engines.

The impact of different national infrastructure fees and taxes on the choice of the transport chains that comprise the different modes, ports and other terminals in and outside Sweden was investigated. The cost minimizing national freight transport model Samgods was used to simulate the impacts of the different national infrastructure fees and taxes including a gate fee per truck as analysed in WP 5 (see Chapter 3.1). For gate fees applied in all Swedish ports, the model predicts an expected increase in transport on rail and road and a decrease in sea transports. Due to the higher costs (for the transfer between road and sea) in ports, gate fees of 200 SEK per truck in all Swedish ports are calculated to reduce the total throughput in all ports by approximately 2%. If gate fees were only implemented in the ports of Gothenburg, Stockholm and Trelleborg the model predicts as expected a different outcome. Both rail and sea transports now increase while road transports

decrease. One explanation for this is that there are ports that compete with these ports in the neighborhood that are used instead.

From a legal perspective, some difficulties have been identified related to the entry fees for trucks. Legal matters related to environmentally differentiated port dues for inland transport in Sweden needs to be further investigated and depend on the detailed design of the proposed charging before conclusions can be drawn on potentials for implementation. When determining if the suggested fees, legally, are classified as a tax, fee, a duty or charges, both national and EU legislative sources need to be assessed. The main criterion for EU is that the fee or tax cannot have discriminatory effects or hinder the free movement of goods or services. A more detailed design of the truck fee is needed to investigate how to implement it from a national legislative perspective. Taxes must be decided by the Parliament, while there are some possibilities to delegate powers regarding fees. The independence of the municipality can also give rise to a municipal decision on fees to a certain extent but depend on the ownership structure of the ports. From a regulatory perspective, a common EU-wide initiative is preferable.

This report also gives an overview of environmental policy measures to explore the possibility to implement environmentally differentiated port dues. National measures analysed in this work covering *all ports* include an environmental tax, an environmentally differentiated state fee, a law on land-based port fee, and a voluntary fee-system set by port operators. *Individual port* measures include congestion taxes, and environmental fees set by the port operator on request by the port environmental permit or in an agreement with the state to get infrastructure investments, inspired by the so called “statsmiljöavtal”, where cities that fulfil objectives related road traffic can apply for public transport investments.

Traditionally, transport policy making has occurred at the national level simply because of the power to implement and enforce. In shipping, existing policy instruments are few largely due to the international characteristics of the business and difficulties in deciding on global instruments. Introduction of port dues globally, or at least in the EU, would include greater incentives for shipping companies and ship owners to invest in emission abatement technologies or use alternative fuels. Measures directed towards land transport could lead to a modal shift, cleaner trucks, and better filling rates and capacity utilization. A national wide coverage may also eliminate unfair competition between different Swedish ports, however being more difficult to adjust to local environmental conditions.

8.2 Further work

The study of inland transport in *Chapter 2 Mapping of environmentally differentiated dues and incentives* contributes to the literature on green ports by presenting one of the first and most comprehensive mapping of port initiatives incentives and fees related to sustainable transport from an inland perspective. The review should be of value for port managers, port related stakeholders and policy makers as it provides knowledge on measures used and how widespread they are worldwide. An evaluation that is needed covers how such measures would be successfully implemented in Swedish ports.

As indicated in the discussions with the expert group and interviews with road hauliers included in *Chapter 3.1 Environmental analysis of incentives for inland transport*, the suggested fee structures were assessed not to be very effective. Further work is suggested to challenge this perception and further

analyse the consequences of different hypothetical port gate fees on a micro level as a complement to the Samgods simulations carried out in this project on a macro level.

If the flexibility on the customer side is as low as hauliers and experts claims and the desired traffic reduction can't be realised without high gate fees, the port city might consider other options to reduce the truck traffic through city areas. One option, suggested for future research, would be to replace present truck transports through the city by a dedicated transport system operated by the port or the terminal operator. This could be realised by establishing 2-3 external transshipment terminals to which present trucks would call for unloading and loading instead of at the port terminal. These transshipments terminals would be located at positions selected so that the driving distances with present trucks in densely populated areas would be minimized, e.g. on the 'hinterland' side of the port city and so that the city centre routes can be avoided. The transport, through the city, between the port and the reloading site could be carried out by trains or dedicated high capacity trucks operating with full load, on designated roads, at controlled times and speeds and with non-polluting and climate neutral engine/fuel combinations. This concept, called 'Extended/City Gates' or 'Close-to-port'-dry ports (see Figure 26 below), has been described in Roso (2013) and investigated specifically for the Port of Gothenburg in Bäckström and Waidringer (2015). The concept is in operation in e.g. Australian and New Zealand ports.

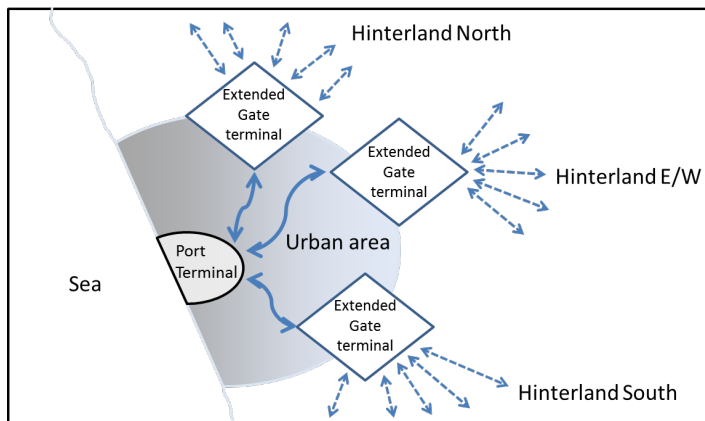


Figure 26 The Extended Gate concept.

The emission calculation model for ships used by IVL in Chapter 3.2 is based on ship call statistics received from the ports. Future work is suggested to include how the emissions could be calculated more accurate for the sea passage. AIS (Automatic Identification System) data would have been useful to compare and validate the results presented in this report. AIS data could be used as a complement to ship call statistics to refine the model with information on actual speed during the voyage. It is also of further interest to analyse how the calculations can be enriched with new information reported according to the EU MRV (Monitoring, Reporting, Verification) regulation that started 1 January 2018²⁵. The ship owners and operators are required to monitor, report and verify aggregated CO₂ emissions and efficiency data.

Chapter 4.1 evaluated the effects of the environmentally differentiated fairway dues in Sweden 1998 – 2017. For the time being, VTI is following up this ex-post analysis. The impacts and effects presented should not be perceived as being solely the causal effect of the environmentally

²⁵ https://ec.europa.eu/clima/policies/ets/monitoring_en

differentiated fairway dues. Some ship operators had already taken measures to reduce emissions before 1998. Furthermore, the implementation of environmentally differentiated port dues in some ports presumably also contributed to influencing the decisions of ship operators to reduce emissions. This yields a potentially interesting extension of the analysis above; to determine to what extent Swedish ports have implemented environmentally differentiated port dues and how these have interacted with fairway dues to influence decisions on reducing ship emissions. VTI has considered such a theoretically interesting extension. However, it is impossible to compile times series data for the period 1998-2017 about which environmentally differentiated ports dues the Swedish ports applied and the impacts of these port dues.

Chapter 4.2 studied the impact on the whole goods transport system of planned and discussed revisions/implementations of different national infrastructure fees and taxes in Sweden in an ex-ante analysis, using a national transport model Samgods. Regarding output variables, the model delivers intuitive results for the throughput in ports (in tonnes) and the modal split (in tonne-km). The modal split results and mode specific emission factors are used to calculate the impact on the different emissions. This approach can be improved by applying vehicle type specific emission factors. Regarding pricing and the design of infrastructure fees and taxes, different parts of the approach need to be developed. One important and constantly recurring issue relates to setting the geographic demarcations (especially for sea transports) for assessing the impact of the external costs. Another aspect is that the internalization of external costs is traditionally limited to the “links” in the infrastructure network. This analysis has shown that there is a need to also include the costs incurred in the ports and in other nodes. In order to facilitate international acceptance and adoption, as a starting point, such methods require agreements to be reached on common definitions and routines.

The Department of Law at Gothenburg University responsible for Chapter 5 Systematization and classification of port dues and its compatibility with national, regional and international regulations recommend continued research regarding the possibility of different incentive structures in relation to differentiated environmental fees. Especially when the incentives include financing of environmental improvement measures through funds, foundations or similar actors. Problems may arise with the duties and powers of the foundations, for example in relations to the local municipal responsibility. In addition, further research is required regarding possible distortions of competition between different actors that may arise due to the model and design of the fees and any discounts and incentives. In addition, incentives, fees and discounts should also be studied on the basis of state aid regulations.

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10. Appendix

Appendix 1. Evaluation form of port related measures for sustainability

Name:

Organization:

Ten potential and feasible measures have been selected; five sea-related and five hinterland related:

Seaside	Hinterland
Case 1: Port dues related to emissions of NO _x	Case A: Air Emissions – Engine
Case 2: Port dues related to emissions of CO ₂	Case B: Acoustic emissions – Improve Knowledge
Case 3: Port dues related to emissions of particles (PM)	Case C: Land congestion – Port dues and subsidy fund
Case 4: Port rebate related to connection to Onshore Power Supply (OPS).	Case D: Modal Shift – Dedicate Infrastructure
Case 5: Port rebate related to slow steaming in fairways	Case E: Intermodal Incentive – Concession Contract

Each measure will be discussed in smaller groups at the workshop, and this evaluation form, which will be collected after the meeting, allows for further personal comments to the project group.

For each example of measure, please indicate your opinion in relation to the defined criteria as well as any comment. The criteria used for evaluation are:

- How big impact do you think this measure can have in terms of enhancing more sustainable transport?
- Would this measure gain industry acceptance?
- How difficult do you think this measure would be to implement?
- Overall, how interesting is it to analyse this measure further in the project?

The score is set according to this 4-level scale:			
4	3	2	1
Very	Somewhat	Not Really	Not at All

SEA-RELATED

Case 1: Port dues related to emissions of NO_x: similar to the system used today by the Swedish Maritime Administration with a stepwise incitement with higher weight of auxiliary engines.

Criteria	Score	Comments
Impact on sustainability		
Industry acceptance		
Difficulty to implement		
Further analysis		

Case 2: Port dues related to emissions of CO₂: either similar to indicators in indexes such as Environmental Ship Index (ESI) or Clean Shipping Index (CSI) or possibly only related to type of fuel used.

Criteria	Score	Comments
Impact on sustainability		
Industry acceptance		
Difficulty to implement		
Further analysis		

Case 3: Port dues related to emissions of particles (PM): either similar to indicators in indexes such as Clean Shipping Index (CSI) or possibly related to type of fuel used or abatement techniques such as filters.

Criteria	Score	Comments
Impact on sustainability		
Industry acceptance		
Difficulty to implement		
Further analysis		



Case 4: Port rebate related to connection to Onshore Power Supply (OPS).

Criteria	Score	Comments
Impact on sustainability		
Industry acceptance		
Difficulty to implement		
Further analysis		

Case 5: Port rebate related to slow steaming in fairways: a rebate is received for reduces speed close to the port city (for instance from the pilot boarding point or a certain distance from the port).

Criteria	Score	Comments
Impact on sustainability		
Industry acceptance		
Difficulty to implement		
Further analysis		

LAND RELATED

Case A: Air Emissions – Engine: rebate for trucks with cleaner engine models. A measure applied in Port of New York and New Jersey.

Criteria	Score	Comments
Impact on sustainability		
Industry acceptance		
Difficulty to implement		
Further analysis		



Case B: Acoustic emissions – Improve Knowledge: educational programs to encourage truck drivers to eliminate noise from air braking at night. A measure applied in Port of Auckland.

Criteria	Score	Comments
Impact on sustainability		
Industry acceptance		
Difficulty to implement		
Further analysis		

Case C: Land congestion – Port dues and subsidy fund: payment of Traffic Mitigation Fee during peak hours at terminal gates. A measure applied in Port of Los Angeles and Long Beach.

Criteria	Score	Comments
Impact on sustainability		
Industry acceptance		
Difficulty to implement		
Further analysis		

Case D: Modal Shift – Dedicate Infrastructure: specific Heavy Weight Corridor for the movement of containers from port region to port terminals. A measure applied in Port of Oakland.

Criteria	Score	Comments
Impact on sustainability		
Industry acceptance		
Difficulty to implement		
Further analysis		



Case E: Intermodal Incentive – Concession Contract: the modal split minimal limits are controlled by the concession contract and exceeding these limits will generate penalties for the terminal operating company. A measure applied in Port of Rotterdam.

Criteria	Score	Comments
Impact on sustainability		
Industry acceptance		
Difficulty to implement		
Further analysis		

Have we missed any highly potential, interesting and feasible measure?

Appendix 2. Environmental impacts of selected indices

Index/Indicator	The Blue Angel	CSI	ESI	Green Award	Green Marine Environmental Programme	Maritime Singapore Green Initiative: Green Technology Programme
CO ₂	X	X	X	X	X	X
Energy efficiency	X	X	X	X	X	
NO _x	X	X	X	X	X	X
SO _x	X	X	X	X	X	X
PM / BC	X	X		X	X	
Hydrocarbons						
Methane						
Antifouling	X	X		X		
Stern tube oils	X	X		X		
External hydraulic fluids	X	X		X		
Gear oils	X	X		X		
Boiler/ cooling water treatment		X		X		
Cleaning agents	X	X				
Refrigerants	X	X			X	
Ballast water treatment	X	X		X	X	
Sewage/ black water	X	X		X		
Garbage handling	X	X		X	X	
Sludge oil handling		X		X		
Bilge water treatment	X	X		X	X	
Crew awareness	X [#]	X		X		
Noise (occupational safety)	X					
Underwater noise	X					
Noise in ports					X*	
Dust emission in ports					X	
Odours in ports					X	
Environmental management systems	X	X		X		
Personnel management+ development	X			X		
Policy and management of the shipping company	X			X		
Ship design and ship equipment	X					
Hull stress monitoring	X			X		
Emergency towing system	X			X		
Ship Operation mgt and tech	X			X		
OPS	X	X				
Extinguishing agents	X					
Ship Recycling	X	X				
Inventory of hazardous materials	X	X		X		
Emissions from cargo	X			X*	X*	
Mooring wire lubrication				X		
Version	RAUL-UZ 110	Version Apr 2017		Version 2014		
Third party verification	Yes	Yes	No		Yes	
Comment	<p>[#]There is requirement for environmental management system (ISO14001), which entails that the management should ensure proper knowledge from its personnel, who should be educated when needed</p> <p>*Only tankers</p>	<p>Scoring available for oil tanker (light or heavy products), general cargo, Reefer, Bulk carrier, RoRo, RoPax, container and car carrier</p>	<p>In house verification Incentive Providers can become auditors.</p>	<p>*For certain relevant ship and cargo types.</p> <p>Scoring available for oil tanker, chemical tanker, bulk carrier, LNG carrier, Container and LPG carrier</p> <p>In house verification</p>	<p>* Only applicable to Great lakes and St Lawrence lakes for international dry bulk carriers.</p>	

Appendix 3. Background information to experts in the elicitation exercise on NO_x-reduction

As previously stated in the project, port dues in Swedish ports vary a lot. A summary shows that the port due per gross ton for vessels over 20 meters is often between 2 and 5 kr. Gross tonnage (GRT) is a measure of a vessel's enclosed volume and does not indicate the amount of goods loaded on the ship. Some examples of ships' GRT are presented in Table 1.

Table 1. Examples of the gross tonnage of three ships.

Ship name	GRT	
Tarndal	Appr. 5 700	
Anina	Appr. 12 000	
Munich Maersk	Appr. 215 000	

Discounts the port dues for efforts to reduce NO_x on vessels vary between ports. There are ports that provide more discounts than we propose here. A big difference from already introduced systems is that this discount is proposed to be given in all ports.

There are some alternative measures for shipping companies that want to reduce NO_x emissions from ships at berth. In order to reduce the emissions significantly, i.e. down to around 2-3 g/kWh, investment in selective catalytic reduction (SCR), exhaust gas recirculation (EGR), shore side electricity connection, or replacement of marine fuel with natural gas (LNG) is required.

The investment costs to clean NO_x on ships are high. Equipping an engine with SCR cleaning can cost between 20 and 100 €/kW and an investment in EGR costs around 30-60 €/kWh (Winnes et al., 2016). The cost differences may depend on the size of the engine as there are economies of scale on the installation of large motors. The price is often lower if investments are made during new building, rather than if an existing vessel is retrofitted with new technical solutions. There are also operating costs, which for an SCR are strongly associated with urea use necessary for NO_x reduction.

Investing in an LNG engine is significantly more expensive than SCR and EGR but can be motivated by a large positive price difference between LNG and other marine fuels.

The investments that are required in order to connect ships to shore-side electricity when at berth are often made jointly by the port/terminal and the ship owner/operator.

How beneficial a discount would be is strongly dependent on the frequency of ships' visits to Swedish ports. Below is a summary of how often ships of different categories visit Swedish ports from a report for the Swedish Energy Agency (Styhre and Winnes, 2016). The statistics are for one year (2014) but can be assumed representative also for later years. The calls are divided into different ship types, of which ships in the RoRo / Ferries category accounts for a majority of the calls. Of these, an absolute main part of the calls is made by ships with some type of NO_x treatment currently on board, usually SCR. We therefore only evaluate the possibility that the ships accounting for the remaining approximately 20,000 calls will reduce their NO_x emissions. We are interested in emissions from ships at berth and, therefore, the issue concerns only reductions of NO_x emissions from the auxiliary engines.

In order to exemplify how to interpret Figur 1 below, here follows a description of the calls made by the category "Tanker":

A total of about 5,000 calls per year are made by tankers in Swedish ports. About half of the calls are made by ships visiting a Swedish port less than 20 times a year. About a quarter of the calls are made by ships visiting a Swedish port between 21 and 50 times a year. The remaining fourth are calls by ships that visit Swedish ports relatively often; more than 50 calls per year to any Swedish port.

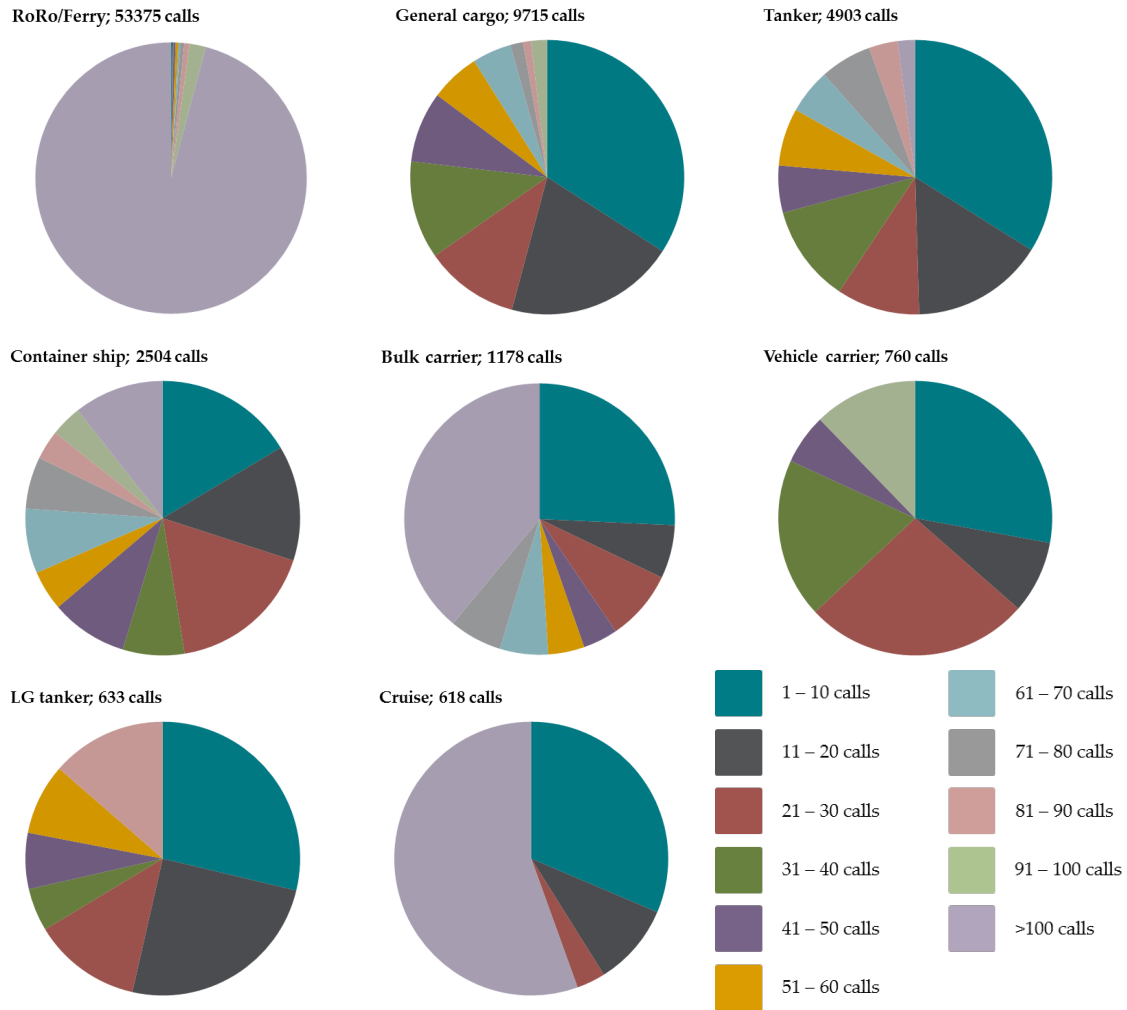


Figure 1. Number of calls to Swedish ports made by different ship types in 2014. (Styhre and Winnes, 2016).

More details on call statistics are reported in Styhre and Winnes, 2016.

References:

Winnes H, Fridell E., Yaramenka K., Nelissen D., Faber J., Ahdour S., NO_x controls for shipping in EU seas, for Transport and Environment, Report U 5552, available at https://www.transportenvironment.org/sites/te/files/publications/2016_Consultant_report_shipping_NOx_abatement.pdf

Styhre L. and Winnes H., 2016, Energy efficient port calls; A study of Swedish shipping with international outlooks. IVL report C212

Appendix 4. Background information to the experts participating in the exercise on slow steaming

Reduced speed at sea, so-called slow steaming, is a measure already applied by many shipping companies to save fuel costs. Speed reduction causes longer time at sea, but a reduction in fuel costs and port due, as well as a reduction in CO₂ emissions. Roughly, fuel consumption increases with the cube of ship speed. This means that there are great savings to be made even if you only slow down the speed with a few knots. Slow steaming therefore sharply reduces the emission of CO₂ from shipping. Limiting the speed of a ship 20 nm from the port entails reduction of fuel consumption and CO₂ emissions to a corresponding extent. Since ships in port often are close to inhabited areas, there are also positive effects from the reduction of SO₂, NO_x and particulate emissions as a result of reduced fuel consumption.

The design of the proposed measure is inspired by the Green Flag Incentive Program (Port of Long Beach, 2018a) in Port of Long Beach, California. In Long Beach, a 15% discount is obtained at reduced speed to 12 knots 20 nm from port. Further, the program gives a 25% reduction of the port due if the speed is reduced within 40 nm from the port. In order to qualify for a discount, shipping companies must prove that at least 90% of the vessels operate at a reduced speed during a calendar year.

More than 95% of the vessels calling Port of Long Beach receive a discount by reducing the speed in the 20 nm zone, and nearly 90% of the vessels receive a rebate according to the 40 nm zone. The speed of each vessel in the zones is controlled by the Marine Exchange of Southern California. According to Port of Long Beach, this has resulted in that 45,000 tonnes of greenhouse gases from ships are avoided annually (Port of Long Beach, 2018b).

In 2014, Swedish ports received approximately 74,000 calls. As shown in Figure 1 RoRo ships and ferries represent the absolute majority of these calls (53375 in total). However, the total number of RoRo vessels and ferries visiting Swedish ports is not that high since the same ships return to ports on regular and fixed timetables. In 2014, container ships made 2504 calls to Swedish ports. More about frequency and bunker consumption for Swedish shipping can be found in Styhre and Winnes, 2016.

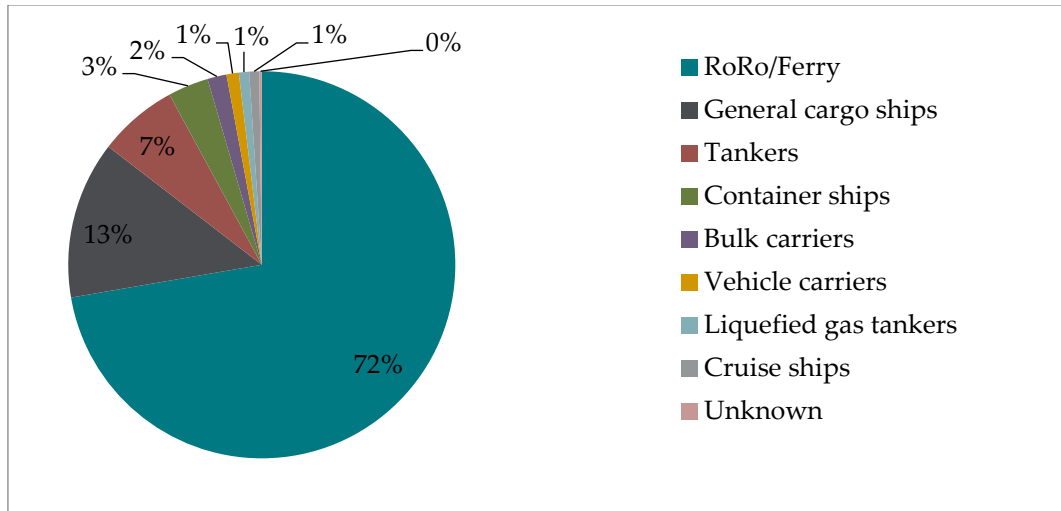


Figure 1. Share of calls in Swedish ports of ships in different categories, year 2014 (Styhre and Winnes, 2016).

In Table 1 we present examples of potential savings in the suggested incentive scheme. The purpose is to show potential savings in fuel costs and from the suggested rebate for ship operators who choose to reduce the speed. Further, the reductions in CO₂ emissions from ships in slow speed near port are calculated. Speed reduction means longer sea time, but a reduction in fuel costs and port due, as well as a reduction in CO₂ emissions. The data refer to both reduced speed to and from the port.

Table 1. The potential to save costs for three example ships. Values are stated as “per call”, i.e. in and out of the port.

	Large RoRo-ship*	Small container ship**	Very large container ship***
Increased time in/out (min)	80	50	80
Rebate from proposed incentive (SEK)	4 800	1 800	15 000
Fuel reduction in/out (tonnes)	4.6	1.9	15.2
Saved fuel costs in/out (SEK)	25 000	10 000	80 000
CO₂-reduction in/out (tonnes)	14.3	5.9	47.1

* calculation input: design speed: 20 knots, size: 32 000 GT, main engine power: 20 000 kW, Port due: 1 SEK/GT, Rebate: 15%, Fuel price: MGO 5 400 SEK/tonne, fuel consumption in design speed: 3.6 tonne/h

** calculation input: design speed: 16 knots, size: 8 000 GT, main engine power: 8 600 kW, Port due: 1.50 SEK/GT, Rebate: 15%, Fuel price: MGO 5 400 SEK/tonne, fuel consumption in design speed: 1.7 tonne/h

*** calculation input: design speed: 20 knots, size: 200 000 GT, main engine power: 66 000 kW, Port due: 0.50 SEK/GT, Rebate: 15%, Fuel price: MGO 5 400 SEK/tonne, fuel consumption in design speed: 11.9 tonne/h

In the “large RoRo ship” and “very large container ship” examples, a speed change operation would entail 80 minutes longer transport time in the zone when 20 knots is decreased to 12 knots. The “small container ship” would need additionally 50 minutes in the zone if the original speed of 16 knots was lowered to 12 knots. According to our example, the total cost savings per call from reduced fuel consumption and rebate on the port due, is calculated to around 30,000 SEK for the larger RoRo vessel, 12,000 SEK for the smaller container vessel and 95,000 SEK for the very large container vessel. The environmental rebate accounts for around 15% of total cost savings. As Table also shows, speed reduction has a positive impact on CO₂ emissions. The potential is highly dependent on initial speed and installed engine power.

References:

Port of Long Beach, 2018a, Web page <http://www.polb.com/environment/air/greenflag.asp>

Port of Long Beach, 2018b, Web page
<http://www.polb.com/environment/air/vessels/default.asp>

Styhre L. and Winnes H., 2016, Energy efficient port calls; A study of Swedish shipping with international outlooks. IVL report C212



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