ETS Study Annex

Carbon Leakage Risk in the Baltic Region

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Executive Summary

European shipping's carbon emissions are comparable to that of Belgium. Yet, legislation to regulate the sector's climate impact is still missing. As such, the European Commission has committed that it will integrate the maritime sector into the bloc's already existing Emissions Trading System (ETS). Carbon leakage - where vessels make evasive port calls to avoid the extra environmental charge - has been raised as an issue for the eventual policy design.

This annex looks in detail at the factors involved in an eventual risk of carbon leakage. It analyses international maritime traffic arriving at and departing from five Baltic Member States and evaluates the risk that vessels trading outside Europe will stop in a non-European port without environmental regulation - in this case the Russian Baltic port of Ust-Luga - in order to drive down their overall costs. Analysis studies the cost factors (operators' earnings, fuel costs, opportunity and port costs) that influence evasion risk at different carbon prices and geographical scopes. Granular analysis then looks in depth at particular case studies to evaluate how the chances of compliance depend on specific factors such as ship class, overall distance length and the location of the port of call.

The overarching conclusion is that under today's (October 2021) carbon prices (€60/tCO_2), there would be no risk of evasion under a semi-full scope covering intra-EU and half of extra-EU emissions. Even under a scenario where earnings drop to their lowest point in the past ten years - where environmental charges would be relatively more significant - evasion risk would be limited to only 2.7% of vessels. This risk increases under a full scope ETS to 16% at today's carbon prices. The results show a lower risk of evasion than in an equivalent study on the ports of Rotterdam, Algeciras and Piraeus. At €40/tCO_2, both studies showed negligible risks of carbon leakage under a semi-full scope. However, at €75/tCO_2, the Baltic region has a 3% risk of avoidance, compared to 11% in the non-Baltic study. At €100/tCO_2, the Baltic region has a 9% risk of evasion compared to 15.6% for the main ports of the Netherlands, Spain and Greece. Results show that this is a result of the majority of non-EU Baltic trade calling at Gdansk and Klaipeda, whose distance from the evasion ports renders evasion economically unattractive.

Analysis shows that a range of factors influence the decision to evade. On the one hand, the location of the port of call is an important factor. At €100/tCO_2, slightly more than 30% of voyages with Tallinn and Sköldvik would be tempted to evade under a semi-full scope, while a negligible number of ships would be tempted to evade Riga, Klaipeda or Gdansk at the same price. On the other hand, analysis of real voyages reveals that there are specific factors related to the vessel that determine the tendency to avoid. Vessel size is particularly important: the smallest bulk carriers (up to 10,000 DWT) have no temptation to make an evasive port call in a voyage from Argentina to Poland under ETS prices up to €384/tCO_2. Vessels in the larger capacity bins are more likely to evade, but even the largest vessels (>200,000 DWT) will not be tempted to evade under €112/tCO_2. Finally, the total length of voyage has a large role in the risk of evasion. Under a semi-full scope ETS, the majority of voyages from non-EU Mediterranean countries, Africa, the Americas and the UK would comply in prices under €100/tCO_2, while around half the voyages from East Asia and Oceania - a small minority of the total traffic - would be tempted to evade. €100/tCO_2 represents a useful metric as a high ETS price estimate for the near future, as well as just under the ETS penalty price of €106/tCO_2.

This analysis does not take into account the possibility that other nations or the International Maritime Organisation (IMO) take even limited environmental action. Similarly, the possibility that vessels will adapt their behaviour to reduce their emissions - for example by slow steaming or technological improvements - is outside the scope considered in this study. The practical experience of evasion is also not considered: in reality the bulkers and tankers (the ship segments that make up the majority of non-European Baltic traffic) are much less inclined to make evasive port calls given the nature of their business: it is practically difficult to find a customer to trade a small amount of goods with at a different port from their final destination.

Nevertheless, these findings present potential lessons for policymakers. Firstly, the risk of carbon leakage is small in both semi-full and full geographic scopes. This lends support to including extra-EU voyages in the EU ETS to achieve the policy's environmental and economic aims.

Secondly, the results reveal that allocating free allowances per energy efficiency - as conducted in stationary ETS sectors - would not address carbon leakage. Free allowances will not address the factors that influence carbon leakage, notably the overall voyage distance, i.e. distance between EU port and non-EU evasion port and ship size. Any system of free allowances based on one or more of these factors would distort the market (in favour of bigger vessel sizes) or give perverse incentives if related to port of call or total voyage distance (by encouraging ships to change their port rather than change their carbon performance). Moreover, the majority of bulk carriers operate in the tramp trade - meaning that they do not make regular trade calls and could even be operating in an entirely different global region each year. As such, from fair competition and environmental perspectives, full auctioning is the most preferable method for emissions allocation.

Lastly, there are clear legislative avenues to deal with the small risk of carbon leakage. The MRV could monitor carbon leakage over a period of time, say two years, and if a significant change of traffic is found, (for instance traffic from a nearby non-EU competitor port significantly increases as traffic from other region decreases), vessels coming from or departing to this port could be obligated to report the next leg of their journey under the MRV and pay for it under the ETS, unless they can prove that the call was not an evasive port call. As complementary measures, the port of call definition in the MRV could be strengthened to mandate 'significant' business activity in that port of call and ships that are repeatedly found to evade could be excluded from any funds arising from a maritime ETS.

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1 Introduction: carbon leakage in maritime transport

International shipping currently contributes around 2.5% of global emissions. The sector is notable for being one of the few to have significantly increased its emissions in Europe since the first measures were taken to tackle GHG emissions in the 1990s. Projects show that emissions from shipping will increase by up to 50% unless measures are taken.[1] In order to regulate European shipping emissions for the first time, European Commission President Ursula von der Leyen confirmed in 2019 that shipping would finally be included in the ETS as part of the European Green Deal. However, when considering the exact design on the maritime ETS, some important issues remain which are in part related to carbon leakage.

In maritime transport, carbon leakage signifies 'evasive' port calls made with the sole purpose of avoiding environmental charges. Given that ships calling at European ports[1] will incur fees proportional to the amount of fuel they use (and thus related to the distance travelled) during the last/first leg of their journeys to the EU, it follows that there is a risk vessels on longer voyages will consider docking at ports outside Europe before arriving or when leaving a European port. To give a concrete example: a vessel originating from the United States may decide to dock in Tanger Med, Morocco, before finally arriving in Algeciras, Spain (Figure 1). In doing so, the only emissions it would have to report to the MRV - and subsequently pay for under the ETS - would be the voyage from Tanger Med to Algeciras, exempting the majority of the emissions from the United States to Spain.

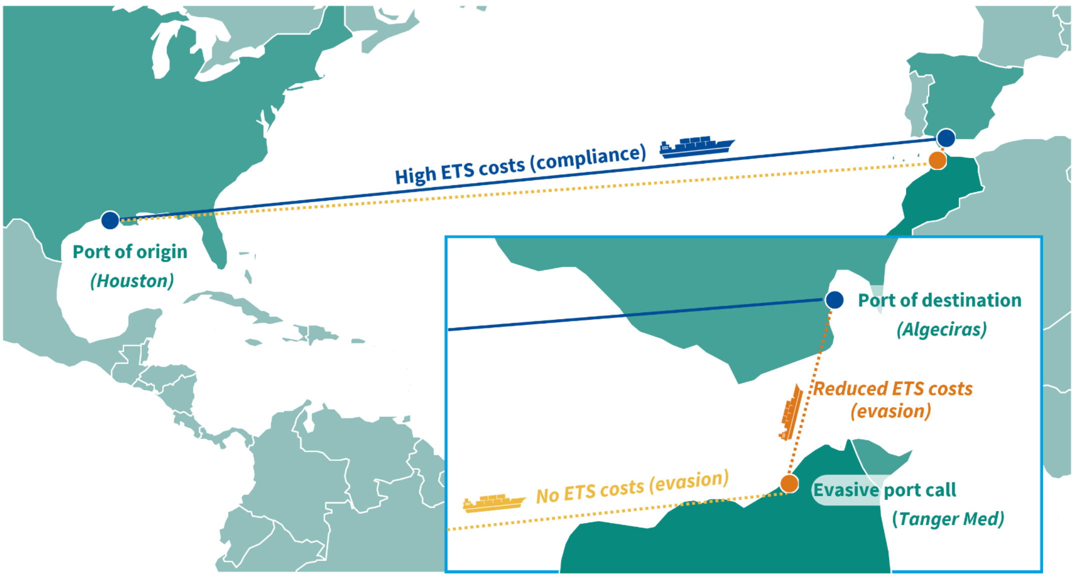


Figure 1: Illustration of an evasive port call

It is important to note, however, that the Monitoring, Reporting and Verification (MRV) legislation includes provisions to safeguard against evasive port calls that this study will not explore. The MRV defines port of

[1] European here is used to designate EEA ports given that this is the geographical scope of the MRV legislation.

call as ‘the port where a ship stops to load or unload cargo or to embark or disembark passengers’.[2] This means that genuine business activity must take place (not including bunkering) and limits so-called ‘coffee break’ evasive port calls made to abuse the system.

Understanding the risk of evasive port calls is important because the potential risk of carbon leakage will influence the political decisions on geographical scope and free allowances. In regards to scope, carbon leakage has been given as evidence in support only applying the ETS to intra-European voyages. Similarly, free pollution allowances are given to the most efficient stationary installations partly to address the risk of carbon leakage. This takes place in sectors that cannot pass costs easily on to the consumer. Therefore, if carbon leakage is shown to not be a significant issue in the shipping sector, then there would be no argument for free allowances in the sector (given that the shipping sector is adept at passing costs onto the consumer).

Analysing the nature of carbon leakage will therefore be key to the design of a successful maritime ETS. To this end, this Annex will look in depth at voyages travelling to the Baltic Sea region and assess the risk of evasive port calls. As Figure 2 shows, the risk to evade is calculated by comparing the extra cost of a carbon charge with the extra costs of an evasive port call. Extra costs include port costs, fuel costs, operational costs and opportunity costs of evasion. Other potential costs such as congestion in the evasion port, high operational costs and high revenues are also taken into account in specific scenarios. The basic assumption of port evasion is that when the total environmental cost for a voyage exceeds the costs associated with evading, a ship operator will prefer to make an evasive port call.

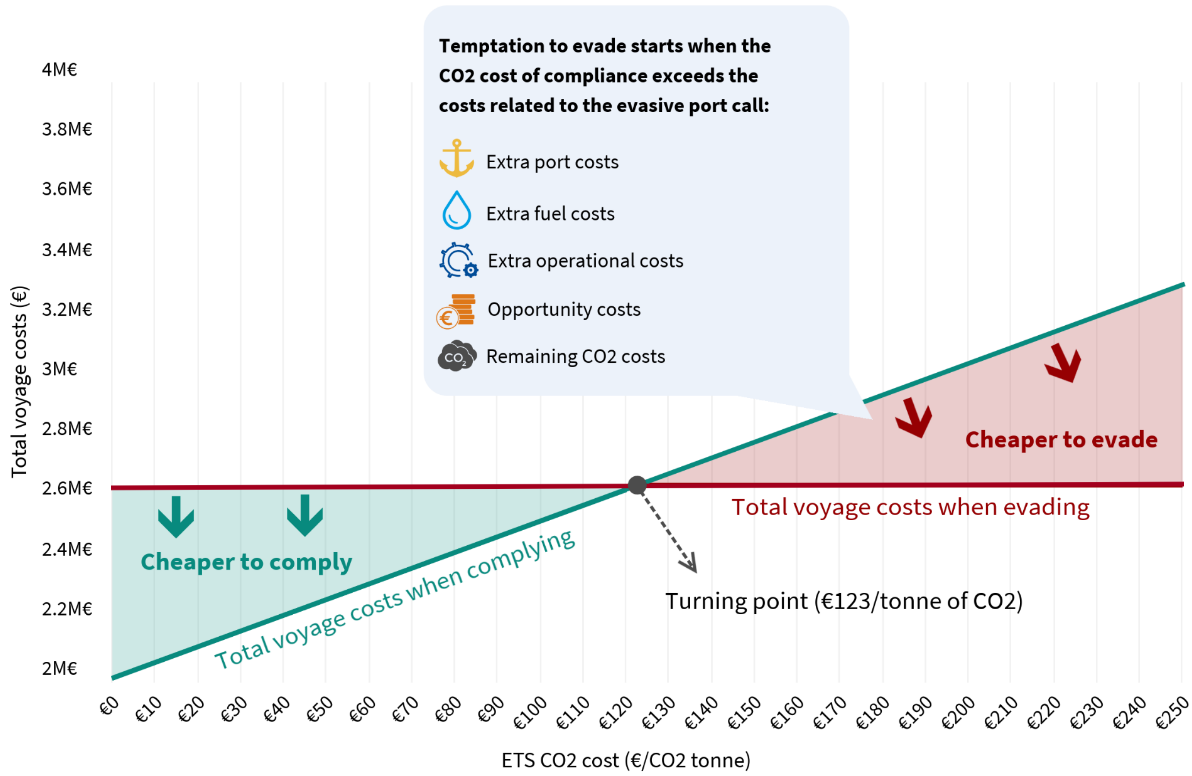


Figure 2: Comparison of total costs to comply or evade the maritime ETS

This Annex investigates the risk of carbon leakage through a base-case scenario and 5 sensitivity analyses that assess the difference in costs between normal voyages and evasive port calls. As detailed in Figure 3, each case explores factors that may have particular impacts on carbon leakage.

Base-case scenario	Historical average prices and port waiting times derived from a literature study.
High/low earnings	A ship's earnings are determined by the price that is charged to put cargo on board of a container ship (freight rates) or by the price to charter a bulk carrier or oil tanker (charter rates). These sensitivities study the impact of an increase/decrease in a ship's earnings on its evasive behaviour by modelling the highest and lowest historical average earnings of the past 10 years (respectively +70% and -40%).
High/low fuel prices	A ship's costs are highly dependent on the fuel price. In these two sensitivities, an increase/decrease of fuel prices by 50% is modelled.
Port congestion	In order to limit their policy compliance costs as much as possible, all ships will be inclined to use the same few nearby non-EEA ports for their evasive port call. This will lead to increased traffic in these ports and thus to the occurrence of congestion. This sensitivity considers a doubling of the time spent in the stopover port. Extra time spent in a port translates into extra operational costs and opportunity costs.

Figure 3: Port evasion scenarios

2 Scope of the report: a Baltic case study

2.1 Countries and ports selected for the case study

This report draws on Transport & Environment's 2020 report on ETS evasion to investigate carbon leakage in maritime traffic operating in the Baltic region.[3] It evaluates the incentive for vessels coming into five EU Baltic member states to evade the ETS: Poland, Lithuania, Latvia, Finland and Estonia. The data come from the Automatic Identification System (AIS) that tracks global shipping movements. This data only provides aggregated voyage information per country, so no information on exact port entry is given. For this reason, it is assumed that voyages arrive at the biggest port of each of these member states in terms of goods handled in 2019 (Sköldvik, Tallinn [Muuga], Klaipeda, Gdansk and Riga). These ports and their amount of cargo handled in 2019 are given in Table 1. Although an EU Baltic state, no Swedish port is included. This is because Sweden's largest port (Gothenburg) does not lie in the Baltic and other possible ports such as Stockholm, at 8 Mt of freight per year, have smaller goods trade volumes than these other ports.

Country	Port	Cargo handling in 2019 (Million tonnes)[2]
Poland	Gdansk	52
Lithuania	Klaipeda	46
Latvia	Riga	32
Finland	Sköldvik	22
Estonia	Tallinn (Muuga)	20

Table 1: Cargo handled in 2019 in main Baltic ports

To put these freight volumes into context, Gdansk, the biggest port of the selection, is the 13th largest EU seaport.[4] Together, the ports considered in this study amount to 172 Mt of cargo in 2019, whereas the top 5 and 10 EU27 ports represent almost 1000 Mt and 1300 Mt, respectively. The three main Russian Baltic ports, Saint-Petersburg, Primorsk and Ust-Luga, trade higher volumes of goods than Gdansk.

Traffic in the Baltic region is dominated by regional trade. This is because the Baltic Sea's geography and hydrology offer no advantage to 'hub' port models such as those of Rotterdam or Algeciras. The region has a relatively larger percentage of TEN-T comprehensive ports than other areas given each port's lower size.[5] RoRo and RoPax vessels have an important role in the region, especially in the transport of people and goods from continental Europe to Scandinavia. The lack of hub ports also means that transshipment is limited and the majority of the trade is short-sea or intra-European (with the exception of segments such as tankers). Container transport with non-European ports is particularly limited. This is because container carriers will most often call at a number of ports in the Baltic and North Sea to increase the amount of goods they carry before departing for transcontinental voyages.

Moreover, maritime traffic in the Baltic region is limited by physical constraints in the Danish Straits region. Shallow seas and difficult navigational conditions led the IMO to designate the Baltic sea a Particularly Sensitive Sea Area in 2005.[6] Vessels above a certain gross tonnage or carrying dangerous goods travelling through the Danish Straits to enter the Baltic Sea are obligated to contract pilotage services. In practice, vessels with a draught above 15m are not able to enter the Baltic Sea.[7]

2.2 Choice of the evasion port

Non-EU ports in the Baltic Sea all belong to Russia: Kaliningrad, Ust-Luga, St-Petersburg Bronka and Primorsk. Although closer to the heart of the Baltic, Kaliningrad was not considered as there is a draught limit of 9 m to 10.5 m, meaning that the biggest ships equipped to carry out transcontinental transport

[2] Sources for each port are listed in the Methodology

cannot enter. All three remaining ports are able to berth larger vessels and, moreover, have extension plans in the coming years.

Saint Petersburg's current maximum draft is 13 m[8] and the port plans to extend its capacity in the coming years.[9] Primorsk port has a maximum draft of 15.85 m. Its current business activity is limited to oil tankers, but similarly plans to develop its infrastructure to accommodate bulk and container vessels.[10] The largest and busiest Russian seaport is Ust-Luga. Although its current draft limits are 13.7 m for bulkers and 12.7 m for containers, it is also planning on expanding in 2024 to accommodate all vessels that can pass through the Danish straits.[11] As such, the Port of Ust-Luga has been chosen as this Annex' evasion port.

It is of note that all Russian ports undercut European ports in terms of port dues. This has allowed those Russian ports to introduce a small 'port investment charge' to support infrastructure development[12] and is significant in the context of carbon leakage as this limits the additional costs of evasive port calls.

2.3 Ships and trade in the Baltics

Voyage data considered in this annex has been limited to the three ship types most active in trade with non-EU ports: containerships, bulk carriers and liquid tankers, amounting to a total of 1,729 individual voyages. The number of voyages for each type of ship and direction of travel (inbound or outbound) are shown in Figure 4. It is useful to note that the trade is dominated by bulk and oil carriers, for whom the risk of evasion is decreased in real life. Similarly, the majority of container carriers trade with the UK, meaning that the risk of evasion for these containers would decrease if the UK took environmental action.

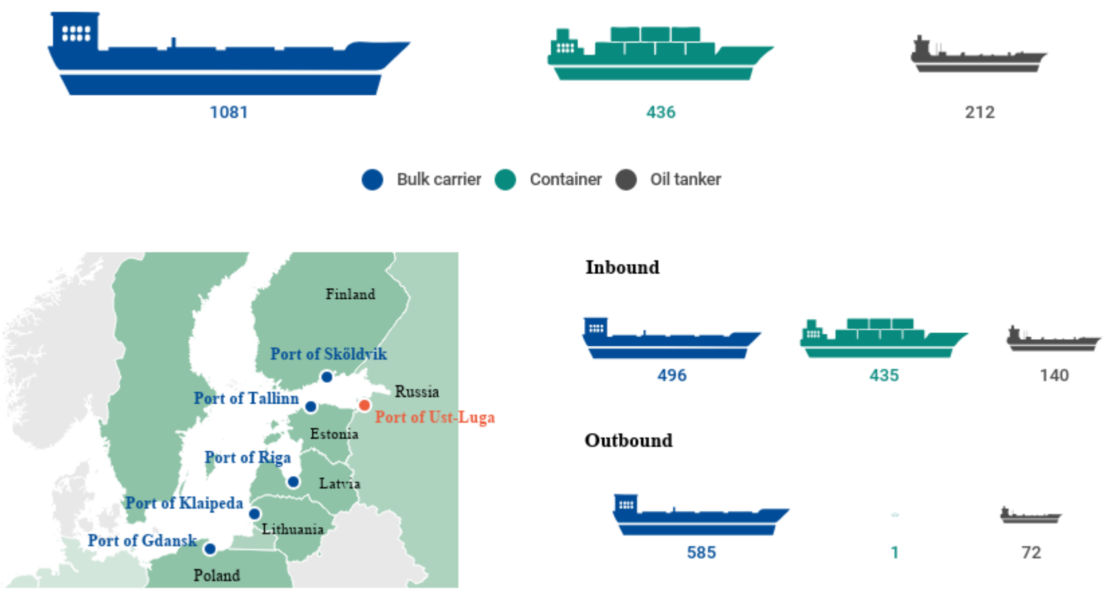
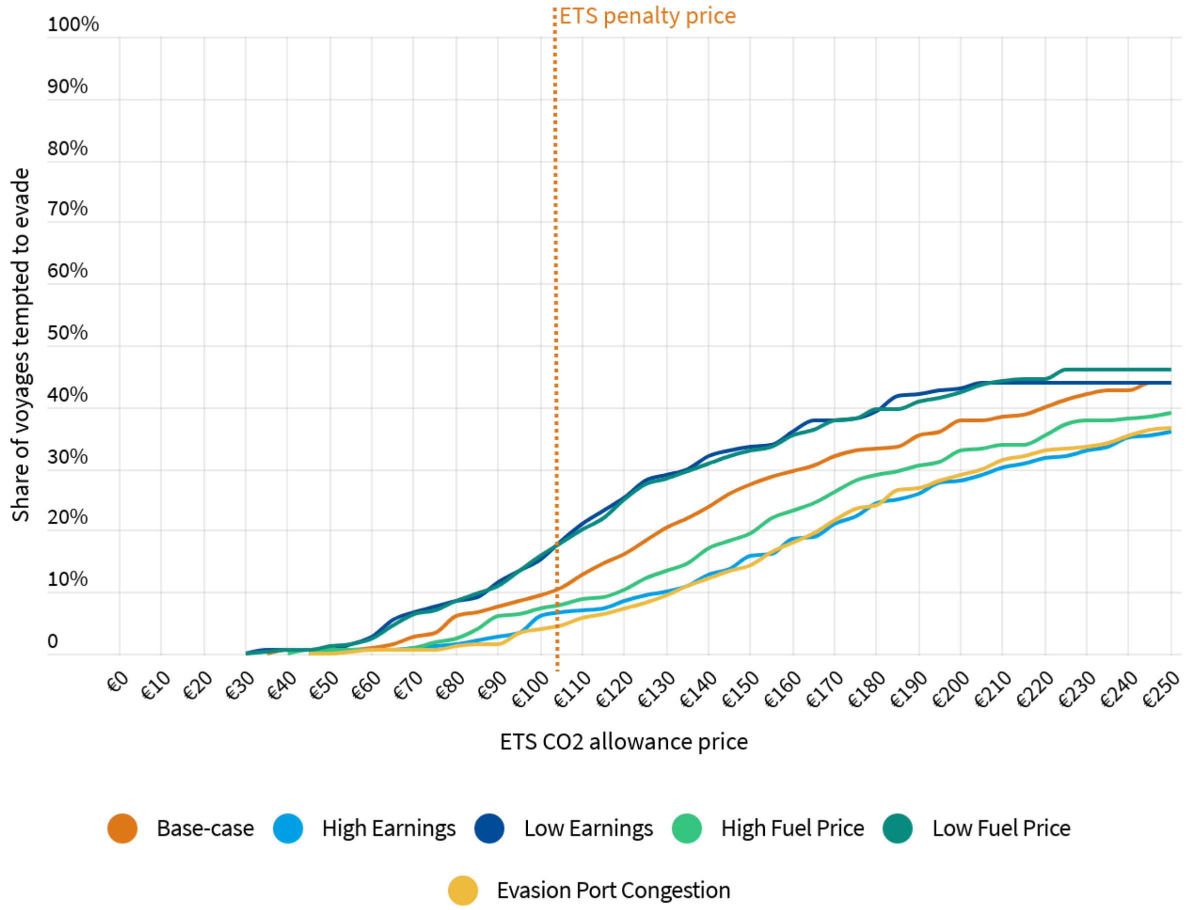


Figure 4: Number of individual voyages to and from the Baltic countries considered in this study and breakdown per ship type

3 Overall results: low risk of carbon leakage for maritime ETS in Baltic region

Results from the Baltic region indicate that the risk of carbon leakage is negligible at politically realistic carbon prices. As Figure 5 shows, under today's carbon prices (€60/tCO_2), there would be negligible risk of evasion under a semi-full scope. Even under a scenario where earnings drop to their lowest point in the past ten years - where environmental charges would be relatively more significant - only 2.7% of voyages would be tempted to evade.

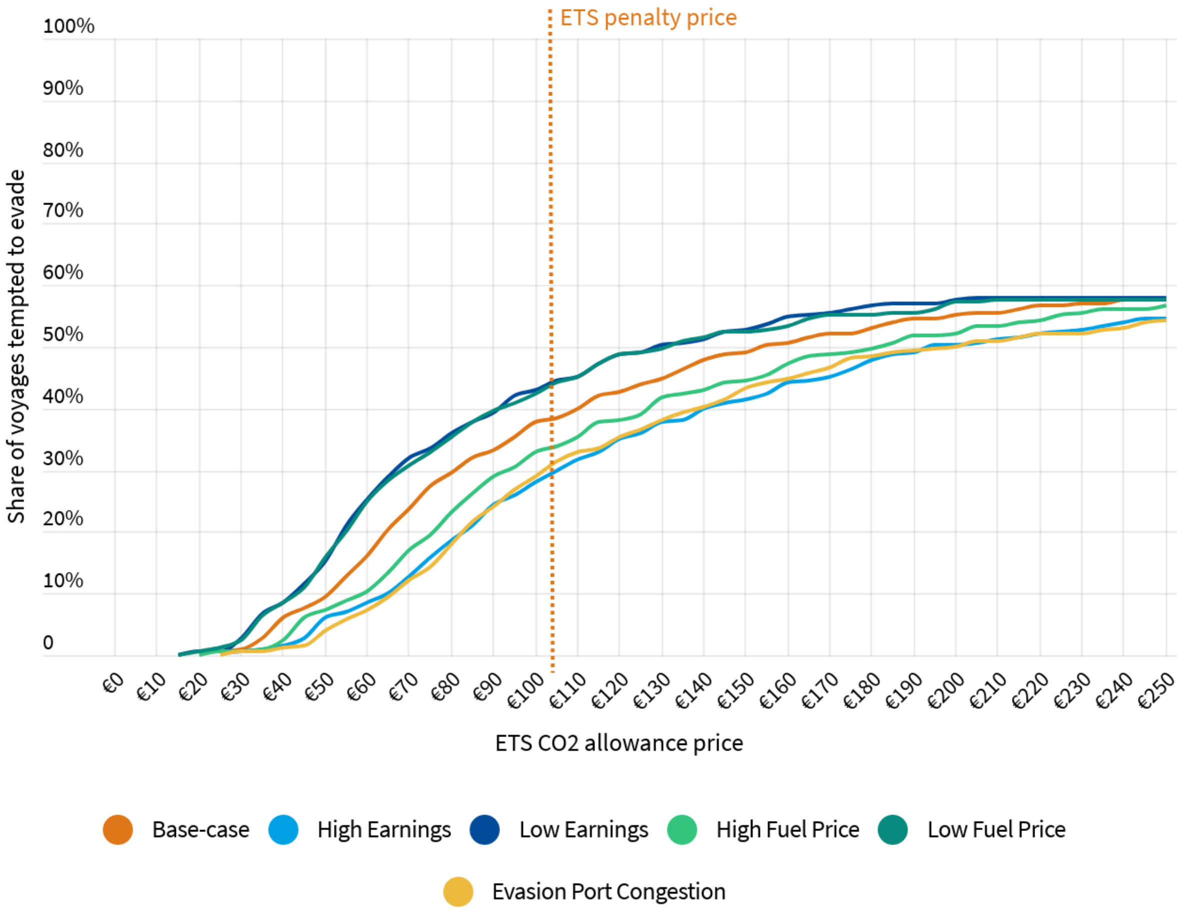


Note: The dotted line, shown for reference, represents the ETS penalty price of €100/tCO2 (€106 adjusted for annual inflation since 2013).

Figure 5: Risk of policy evasion under a semi-full scope maritime ETS covering Baltic countries. The dotted line, shown for reference, displays the ETS penalty price of €106/tCO_2, adjusted to inflation from 2013 price of €100/tCO_2

Even at high carbon prices, risk of evasion remains low under a semi-full scope ETS. At the cost of €100/tCO_2, evasion is profitable to around 1 in 10 voyages. Even under the low fuel price and low earnings scenarios, the risk of evasion remains under 20% at €100/tCO_2 carbon price.

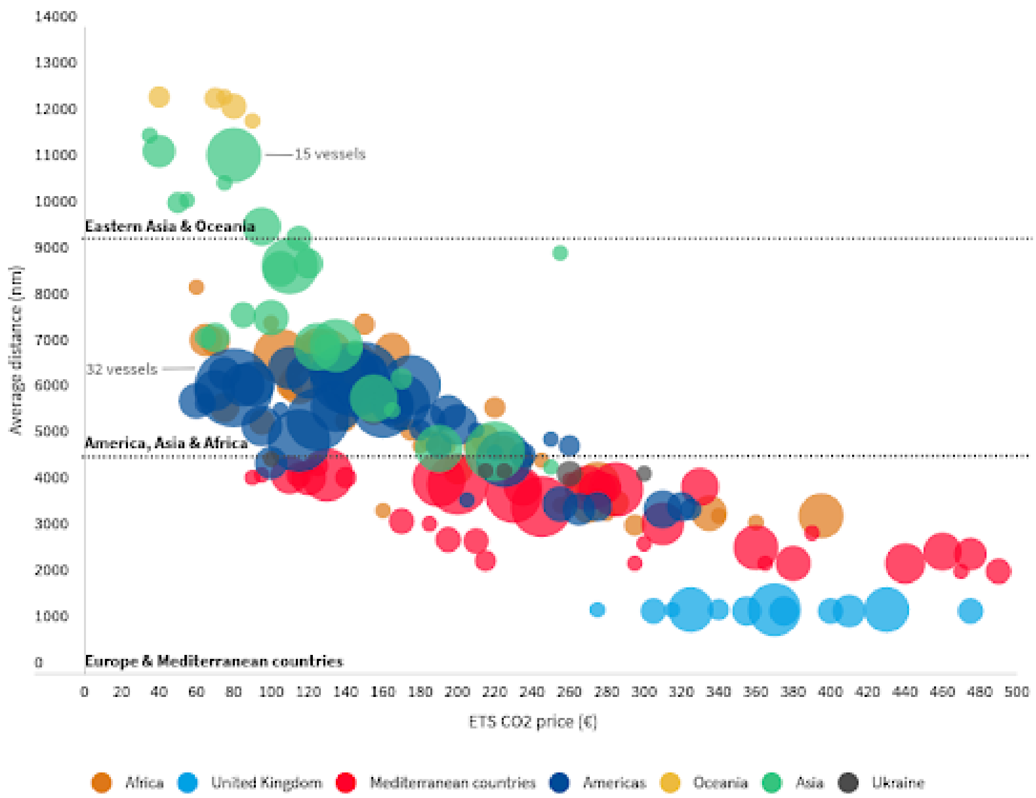
Under a full scope ETS (Figure 6), the risk of evasion rises to 38% at €100/tCO_2 in the base-case scenario. In the worst case scenarios (low earnings or low fuel price), 43% of voyages would be tempted to evade at €100/tCO_2, while in high earnings and port congestion scenarios, the risk would be around 30%. At today's carbon prices (i.e. €60/tCO_2), however, the risk is 16% under the base case, rising to 25.3% in the case of low earnings. If port congestion or high earnings factor in, the risk is around 8%.



Note: The dotted line, shown for reference, represents the ETS penalty price of €100/tCO2 (€106 adjusted for annual inflation since 2013).

Figure 6: Risk of policy evasion under a full scope maritime ETS covering Baltic countries

The results are broadly in line with results from T&E's 2020 study on port evasion in the ports of Rotterdam, Algeciras and Piraeus. In that study, the risk of evasion was in general higher. Under a semi-full scope, at €40/tCO_2 a negligible amount of vessels were tempted to evade. At €75/tCO_2, 11% were tempted to evade the non-Baltic ports compared to 3% in the Baltic ports and at €100/tCO_2, 15% would evade non-Baltic ports against 9% evasion risk in the Baltic region.



Note: The colors represent the origin or destination of the vessels calling at Baltic ports. The dotted lines indicate the span in sailing distance between these regions and the Baltics. The size of the bubbles indicates the number of vessels sailing from and to the Baltics that might find it financially attractive to evade at any given CO2 price.

Figure 7: Origin and destination of real voyages calling at Baltic ports and their turning points (semi-full scope ETS)

Figure 7 details the turning points - the CO_2 price at which it becomes financially attractive for a ship to evade - and the origin or destination of the voyages entering Baltic ports under a semi-full scope. The results demonstrate that all journeys calling directly to or from Oceania would find evasion financially attractive at prices under €100, however, they form a very small amount of the total voyages. In contrast, the majority of voyages to or from non-EU Mediterranean countries, Africa, the Americas and the UK - accounting for the majority of trade - would not be tempted to evade at ETS prices under realistic estimations for the near future (lower than €100).

Figure 8 shows the same data under a full-scope ETS. In this case, the majority of the voyages from the Americas as well as those from Asia would be tempted to evade at CO_2 prices under €100. Voyages from the UK and the majority of non-EU mediterranean voyages are still not tempted to evade even at carbon prices above €100. The majority of voyages from all regions bar Oceania would still comply at current CO_2 prices (€60/tCO_2).

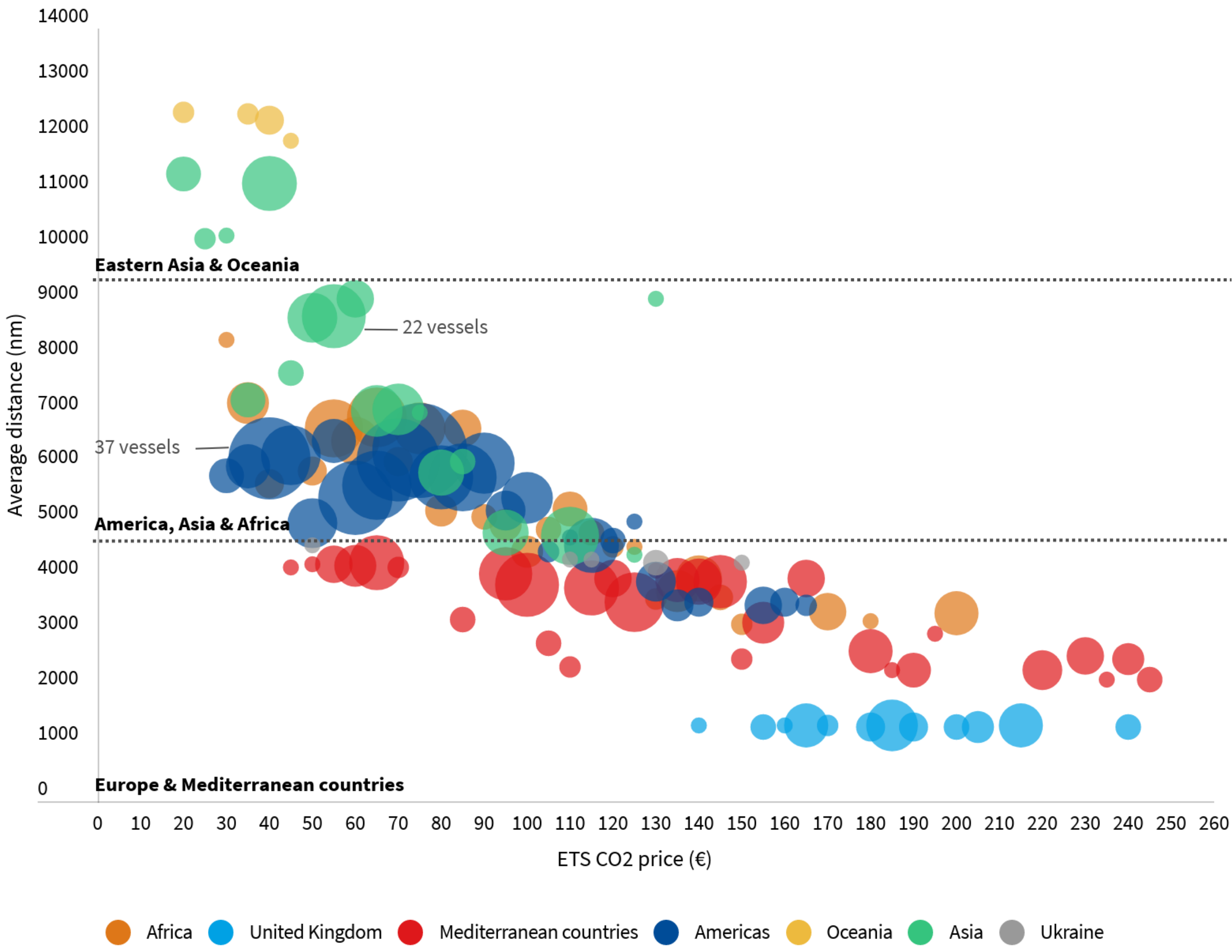


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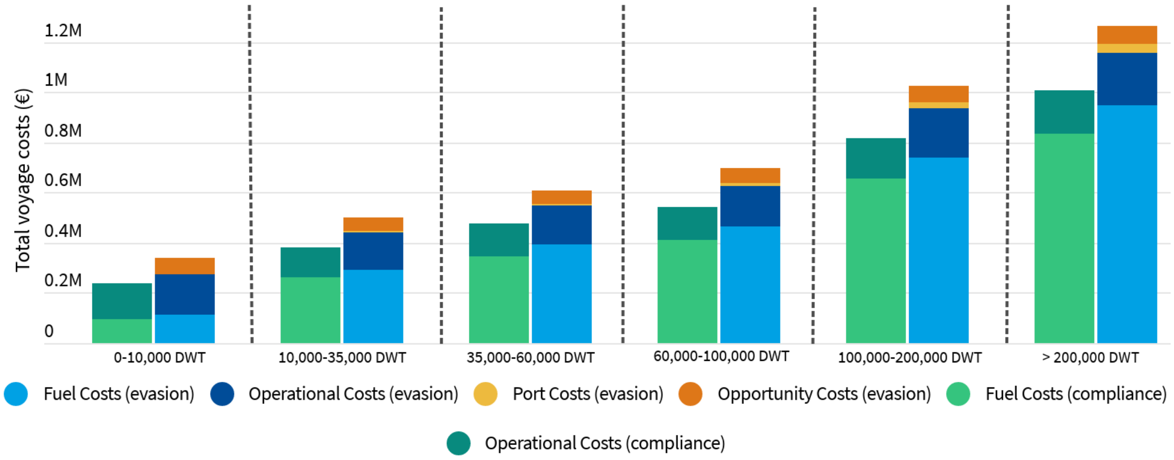
Figure 8: Origin and destination of voyages calling at Baltic ports and their turning points (full scope ETS)

4. Case study of a bulk carrier sailing from Argentina to Poland

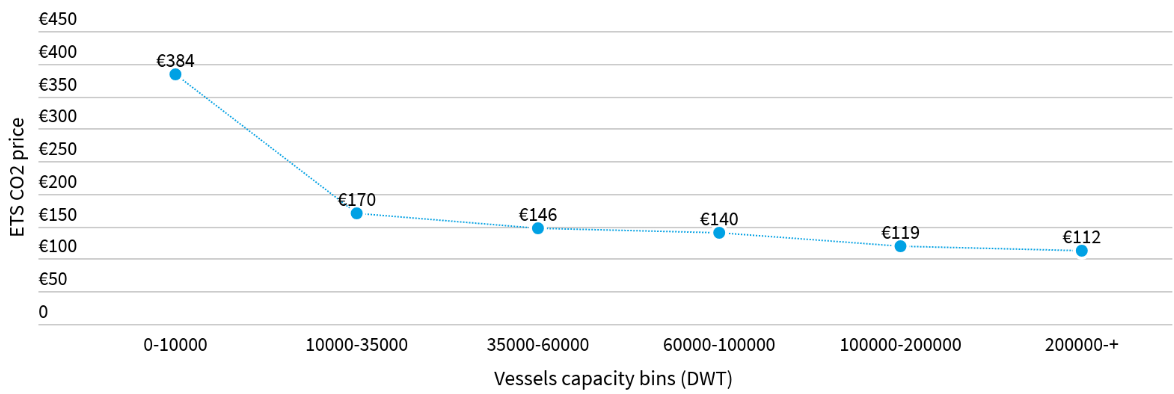
In order to collect granular information on carbon leakage, this report also looks into the case study of one real-life voyage. This provides greater detail into the prices and factors leading to carbon leakage. The voyage chosen is of a bulk carrier travelling from Buenos Aires in Argentina to Gdansk in Poland potentially carrying grain for agriculture or heavy goods such as ore to be used in construction or manufacturing. In 2016 the voyage was made 11 times by vessels between 35,000 and 100,000 DWT. The cost data has been analysed and the results are presented in Figure. 9; the smaller and larger vessels being simulations for what would have happened if vessels smaller than 35,000 or larger than 100,000 DWT have sailed between Argentina and Poland, too. The analysis looks in detail into the cost breakdown of evasion and compliance to show the relative importance of each factor in a vessel's decision to comply.

In Figure 9, the top graph illustrates the cost structure of a bulk carrier before any CO_2 price is applied. For each size category, the column on the left shows the cost breakdown without an evasive port call (i.e. compliance costs) and the column on the right shows the increase in each of those costs when an evasive port call is made. The second graph depicts the turning points for each of those bulk carriers. All of these vessels are sailing on the same route from Argentina to Poland. The bulk carriers of 35,000-60,000 DWT and 60,000-100,000 DWT represent real-world operational activity (2016) of ships calling at Polish ports These journeys are comparable to the scope of the EU MRV regulation. All the other bulk carriers are simulations.

As opportunity costs don't increase much by size...



... the smallest bulk carriers will be the last ones to evade



Note: The top graph illustrates the cost structure of a bulk carrier before any CO2 price is imposed. For each size category, the column on the left shows the cost breakdown without an evasive port call and the column on the right shows the increase in each of those costs when an evasive port call is made. The second graph depicts the turning points for each of those bulk carriers. All of these vessels are sailing on the same route from Argentina to Poland. The bulk carrier of 35,000-60,000 DWT and 60,000-100,000 DWT represent real-world operational activity (2016) of ships calling at Polish ports These journeys are comparable to the scope of the EU MRV regulation. All the other bulk carriers are simulations.

Figure 9: Cost structure and turning points of bulk carriers sailing from Argentina to Poland (semi-full scope base-case)

Figure 9 illustrates that fuel costs are relative to a ship's size and so increase the larger the ship. The most important extra costs associated with evasion are the opportunity costs (the foregone revenue of extra time that was lost by rerouting away from the final destination), which increase by around 25% from the smallest to largest ship sizes, and extra fuel costs. For ships over 200,000 DWT, evasion becomes attractive at a carbon price of €112/tCO_2. This is because bulk operators' opportunity costs are accrued as a function of extra charter days needed to transport the same amount of cargo and charter rates do not vary greatly by ship size. The opportunity costs for larger vessels, therefore, do not differ too much compared to smaller vessels, leading to relatively lower turning points for larger vessels compared to smaller ones. This conclusion is echoed by Figure 10, which shows the cost breakdown relative to different carbon prices for a bulk carrier of 60,000-100,000 DWT.

Opportunity costs have a major influence on ETS evasion for bulk carriers

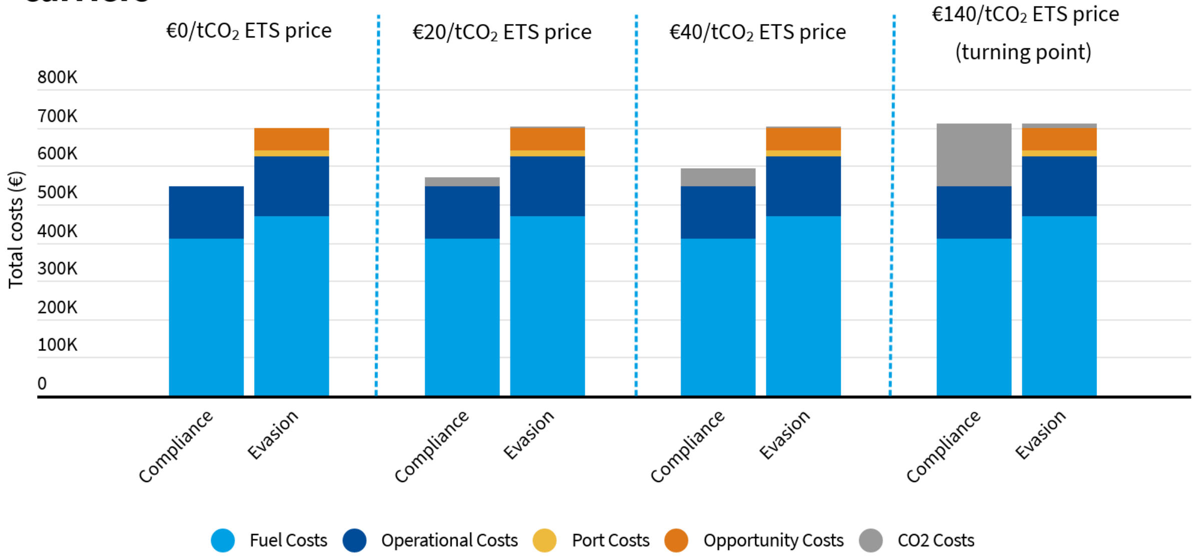


Figure 10: Compliance vs. evasion costs for a bulk carrier of 60,000-100,000 DWT sailing from Argentina to Poland, for different ETS prices (semi-full scope base-case)

5. Evasion distance as a function of the ETS price

In this section, we analyse the influence of the position of the port of call by calculating from what distance between the ETS-participating port of call and the evasion port ships will be tempted to evade. This analysis is not as granular as the case study as it does not take into account the experience of real-life voyages or other factors such as shipping segment or size. Nonetheless, it can provide clues as to the influence of distance from the competitor port.

The concept of evasion distance is represented in Figure 11. For a given ETS price and non-ETS-participating departure or arrival port, we calculate an evasion distance, meaning that voyages arriving at or departing from an ETS-participating port closer than this distance from the evasion port will be tempted to evade. In the case of Ust-Luga, an evasion distance of 150 nm would mean that a ship calling at the port of Tallinn would be tempted to evade. An evasion distance of 500 nm would still be insufficient for ships calling at Gdansk to evade. More information on how we calculated the evasion distances for different voyages and ETS prices can be found in the methodology section.

Figure 11: Evasion distance: representation of distances of 150 nm and 500 nm from the port of Ust-Luga

Figure 12 shows evasion risk expressed as distance from the Port of Ust-Luga under a semi-full ETS scope. The results demonstrate that just under a third of ships would be tempted to evade at an ETS price of €100/tCO_2 if their port of call was 150 nm from the evasion port (roughly the distance of Tallinn, 155 nm, and Sköldvik, 128 nm).[3] As the distance increases, the share of ships willing to evade drops quickly and a

[3] Distances calculated using Sea Routes (https://classic.searoutes.com/routing?speed=13&panama=true&suez=true&kiel=true&rivers=block&roads=block)

negligible number of ships is tempted to evade Gdansk (528 nm) or Klaipeda (450nm) or Riga (348nm) under €100/tCO_2. These results demonstrate that although evasion risk is elevated at ports closer to the competition port, the risk is still negligible for the Baltic regional traffic as a whole As in Figure 5, only 3.7% of voyages would be tempted to evade Tallinn or Sköldvik at ETS prices of €60/tCO_2.

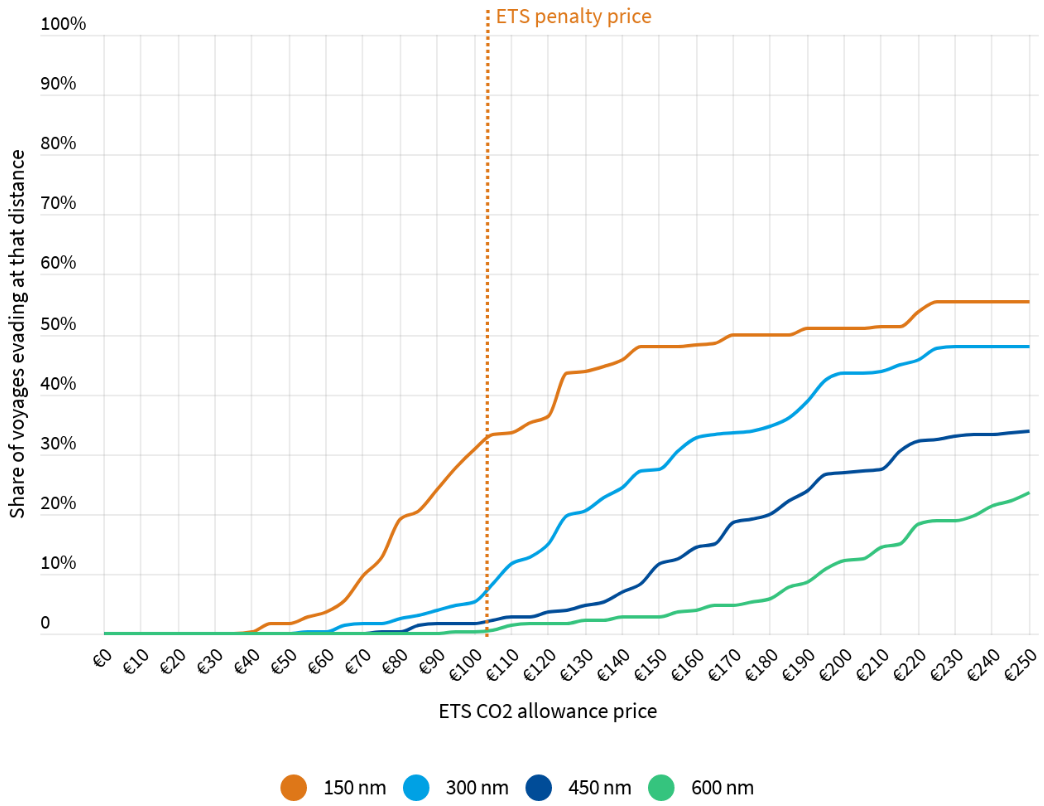


Figure 12: Share of voyages willing to evade if their ETS-participating port of call was at a certain distance from Ust-Luga (semi-full scope ETS)

Further analysis on the factors influencing a vessel's decision to comply can be drawn by looking in detail at a number of voyages into a few voyages as observed in AIS data (see Figure 13). The voyages analysed are:

- A bulk carrier travelling to Canada (St John's) (35,000-60,000 DWT)
- A bulk carrier traveling to Peru (Callao) (35,000-60,000 DWT)
- An oil tanker coming from Turkey (Haydarpasa) (120,000-200,000 DWT)
- An oil tanker coming from United States of America (Houston) (120,000-200,000 DWT)

Given that distance correlates to fuel use and thus carbon emissions, it follows that the longer the journey, the more likely ships would be to call at Ust-Luga in order to avoid the higher ETS charges. Figure 18 charts the points at which evasion becomes attractive the further away from Ust-Luga.

Vessels travelling the longest journey - to Callao in Peru - will be tempted to make an evasive port call after Tallinn at a carbon price of €78/tCO_2 but would not be tempted to evade other Baltic ports at prices under €150/tCO_2. In contrast, vessels travelling the shortest route to St Johns, Canada, would not be tempted to evade Tallinn until prices much higher than €100/tCO_2. These results reveal that although Tallinn and Southern Finnish ports would be most at risk of evasion given their close proximity to the Russian competitor ports, the practical risk of evasion is negligible under current carbon prices.

Figure 13: Evasion distance as a function of the semi-full scope ETS price for voyages from/to different ports outside the EU. The y-axis represents the theoretical departure port, with the dotted lines displaying the nautical miles of relevant ports from Ust-Luga

6 Conclusions

This study has looked into the economics of carbon leakage under a maritime ETS. Analysing a series of scenarios, including high earnings, high fuel prices and congestion in evasion ports, the study has picked apart the factors that would influence a vessel operator to decide to comply with an environmental charge or evade it through a port of call outside the EU. Granular analysis has also been carried out on historical voyages to explore the motivations per ship type and distance from the evasion port.

The results demonstrate that integrating the maritime sector into the ETS would not lead to significant carbon leakage. Even under ETS prices of €100/tCO_2, only 9% of voyages would be tempted to evade under a semi-full scope ETS. This rises to 38% under a full scope. For both bulk and oil carriers, the temptation to evade increases with the size of the vessel , the overall voyage distance and the distance from the non-EU competitor port. The risk is less than the equivalent risk in the ports of Rotterdam, Algeciras and Piraeus; at €75/tCO_2, there is a 3% risk in the Baltic sea compared to an 11% in the main ports of the Netherlands, Spain and Greece. At €100/tCO_2, risk increases to 9% in the Baltic region, but 15.6% in the other ports studied. On the one hand, this is due to the shorter distances between Rotterdam, Algeciras and Piraeus and their non-EU competitor ports (the majority of non-EU Baltic traffic is concentrated away from the Gulf of Finland where the Russian ports are located). On the other hand, this is a reflection of the difference in trade: there is a greater concentration of smaller bulkers and tankers in the Baltic region, which have lower incentives to evade.

When drawing conclusions from these findings it is important to underline that the practical risk of evasion will be lower than what is found in this study given the definition of port of call in the MRV legislation. That regulation ensures that vessels must conduct business activity in ports, and cannot call at a port for the sole purpose of avoiding the environmental charge or even refuelling.

This is important because, as Figure 4 shows, the Baltic Sea trade with non-European locations is dominated by bulk and oil carriers: the vast majority of container carriers considered trade with the UK. So if the UK took environmental action, container traffic between non-European ports and Baltic ports would all but disappear along with the risk of evasion in this sector. Although a container carrier may theoretically be able to unload a small part of its cargo in order to avoid an ETS charge, this is practically much more complicated for bulk and liquid carriers. These vessels usually operate in door-to-door cargo transportation for a single client. In contrast, container ship voyages seldom go directly to their destination, instead stopping off frequently along the way. For this reason, there is limited direct container traffic between Baltic ports and non-European ports and the ETS will not affect these voyages. In contrast, from a business perspective it is difficult for bulk and oil carriers to divert from their predetermined route. This perspective has been left out of this study but is important to consider when evaluating the absolute risk of carbon leakage.

Finally, this study does not take into account any eventual emissions reductions measures a ship may take to reduce environmental costs (via slow steaming, energy efficiency technologies or the use of sustainable alternative fuels) and assumes that no action is taken in other regions or globally. As such, a number of other factors make the findings in this report conservative and make carbon leakage more unlikely in practice than on paper.

7 Policy Recommendations

This study provides a number of lessons for policy-makers. Firstly, both environmental coverage and revenues will not be affected by limited carbon leakage in relatively high carbon price scenarios. This means that carbon leakage does not weaken the maritime ETS proposal at either a full or semi-full scope.

- **Risk for maritime ETS evasion is very low under realistic CO_2 price scenarios, so policy-makers should strive for an ambitious geographical scope not limited to intra-EU voyages**

Turning to the method of allocation, this study has shown that the main factor behind carbon leakage is distance, given the traffic analysed in the Baltic region. Therefore, awarding free allocations would only address the residual risk of carbon leakage if they were given based on distance travelled or port of call. This becomes politically difficult in subsidising some regions over others, destabilising shipping's level-playing field. Furthermore, it may concrete perverse incentives by pushing some voyages to those port destinations that receive free allowances. As such, the fairest allocation method would be full auctioning in fiscal, competition and environmental terms.

- **Full auctioning is the most preferable method for emissions allocations**

The risk of limited carbon leakage is concentrated in certain ports closest to competitor non-EU ports. A legislative solution to deal with these competitor ports should therefore be considered. In this context, there is flexibility to adapt the MRV legislation to oblige vessels to report voyages beyond those calling at a European port.[14] This could be done by monitoring results from the MRV over a period of two years. If significant change of traffic is found (such as a significant growth in traffic with a nearby non-EU port at the expense of traffic from other regions), then ships would be obligated to declare the next leg of their journey to or from this competitor port under the MRV and pay for it in the ETS. Those vessels could be exempted from payment if they can prove that the port call was not evasive. Alternatively, or as a complementary measure, the definition of 'port of call' in the MRV could be strengthened to accept only those port calls where a significant percentage of goods are docked or undocked. This would further reduce the incentive for cynical evasive port calls.

In some cases, vessels engaging in evasive port calls would not call at a European port. This is the case in particular for container vessels operating in the transshipment business. In this scenario, a large ship would shuttle from two large ports, such as Shanghai and Algeciras, carrying a large amount of containers which would be left at the port then picked up by feeder vessels and taken to their final European locations. If these vessels chose to evade the ETS, they would shift their traffic to a deep sea port with similar capacity. Transshipment traffic occurs most commonly at deep sea ports located on major sea routes. Given the limited number of ships able to call in the Baltic Sea, this type of carbon leakage is not a possibility in that region. In practise, the only port at risk of this type of evasion is Algeciras, at risk from Tanger Med in Morocco.

While the vessels making the evasive port calls (e.g. from Shanghai to Tanger Med rather than Algeciras) cannot be regulated - given that they do not call at a European port before or after the evasive port call - the feeder vessels that bring that cargo to Europe can. Those feeder vessels enable the carbon leakage of the full voyage from Shanghai to Tanger Med and so can be regulated accordingly.

The solution is as such: the MRV will monitor change in traffic over a period of two years. If significant change is reported in a ports' transshipment activity, then all container traffic coming from the evasion port into **any** European port will be charged a penalty factor on their ETS payments (e.g. 5 times the market ETS price to deter evasive behaviour). If these ships can prove that more than 90% of their goods originate in the evasion port, then it will be exempted from payment. This proof is simple and can be done using bills of laden or other relevant commercial documents. If they cannot provide this proof, then they will pay the multiplier.

- **As a backstop against carbon leakage, results from the MRV could be monitored over two years. If significant change of traffic is found then ships would be obligated to declare the next leg of their journey to or from this competitor port under the MRV and pay for it in the ETS. Vessels could be exempted from payment if they can prove that the port call was not evasive**

- **For transshipment carbon leakage, a multiplier could be applied to all feeder vessels bringing containers from the evasion port to any European port**

- **At the same time, the 'port of call' definition in the MRV could be strengthened to mandate significant business activity**

The findings on revenues are significant given the push from NGOs, industry and the European Parliament to set up an 'Ocean Fund' with the maritime ETS revenues. This fund would be destined for reinvestment back into the sector, meaning that R&D or the deployment of fuels and technologies would benefit no matter the carbon price. This study should therefore give a renewed push to make an Ocean Fund a key part of the maritime ETS proposal.

In addition to the legislative solutions to carbon leakage listed above, companies that persistently make evasive port calls could be barred from access to these funds. This would mean that if a company operates a vessel that after two years monitoring of the MRV is suspected of making evasive port calls and does not demonstrate the contrary, it would be listed as an evasor. If this operator does not comply with the ETS in a significant share of its voyages to ports at risk of evasion, it would be excluded from funds from the maritime ETS.

- **Funds from the maritime ETS will be significant and can support decarbonisation especially if channeled through a dedicated Ocean Fund**

- **Excluding operators found to repeatedly make evasive port calls from the ETS funds can help further deter carbon leakage**

8 Appendix - Methodology

To understand the analysis undertaken in this study, the reader will first refer to our original ETS evasion study [3] and its methodology section. Below, we will list the modifications brought to the model to get the results presented in this report.

The Data sources for the amount of data handled (Table 1) are:

- Gdansk: https://www.portgdansk.pl/en/business/general-information/facts-and-figures/
- Klaipeda: https://www.portofklaipeda.lt/index.php?page=uosto-statistika
- Riga: https://rop.lv/en/port-statistics
- Sköldvik: https://www.finnishports.fi/eng/statistics/monthly-statistics/?stats=monthly&changes=rolling&T=0&year=2019&month=12&sort=2&dir=desc
- Tallinn: https://www.ts.ee/wp-content/uploads/2020/01/Tallinna-Sadam-Q4-2019-ENG.pdf
- Sweden: https://www.transportforetagen.se/contentassets/f579f131ea244968853cb65724344311/sveriges-hamnar-2020q4_210317.pdf?ts=8d8e92b46959980

8.1 Evasion port costs

The following port costs were calculated for the port of Ust-Luga, based on the information available publicly on https://www.rosmorport.com/filials/spb_serv_loc/.

Bulk carrier capacity bin (DWT)	Port Costs (€)	Port Costs (€/GT)
<10,000	870.32	0.41
10,000-35,000	5,150.74	0.30
35,000-60,000	9,335.54	0.31
60,000-100,000	13,845.30	0.33
100,000-200,000	27,067.73	0.31
>200,000	38,934.41	0.30

Oil tanker capacity bin (DWT)	Port Costs (€)	Port Costs (€/GT)
<5,000	2,467.44	2.09
5,000-10,000	3,537.90	0.77
10,000-20,000	5,248.25	0.53
20,000-60,000	10,529.24	0.38

60,000-80,000	14,169.02	0.34
80,000-120,000	19,498.03	0.32
120,000-200,000	25,859.29	0.31
>200,000	48,261.34	0.30

Container capacity bin (TEU)	Port Costs (€)	Port Costs (€/GT)
<1,000	2,042.64	0.32
1,000-2,000	5,256.60	0.35
2,000-3,000	7,938.60	0.29
3,000-5,000	11,120.32	0.26
5,000-8,000	16,483.25	0.24
8,000-12,000	23,198.21	0.23
12,000-14,500	32,721.12	0.22
>14,500	41,552.58	0.22

8.2 Evasion distance calculation

Based on the equation characterizing the evasion turning point:

$$(FuelCost_C + OpeCost_C + CO_2Cost_C) = (FuelCost_E + OpeCost_E + CO_2Cost_E + OppCost_E + PortCost_E)$$

where:

- *C* and *E* indices refer to the compliance and evasion case, respectively
- *FuelCost* is the fuel cost
- *OpeCost* is the operating cost
- CO_2Cost is the cost of emissions under the ETS scope
- *OppCost* is the opportunity cost
- $PortCost_E$ is the port cost related to the stop in the evasion port

we determined the following equation to approximate the evasion distance ***ED***:

$$\left(FuelCost_{BaU} + OpeCost_{BaU} + CO_{2BaU} * ETSPrice \right) * \frac{d_{E,LL} - \boldsymbol{ED}}{d_{BaU}}$$
$$= FuelCostPerTonne * FuelCons_{E,port} + FuelCostPerTonne * FuelCons_{E,sea} * \frac{d_{E,LL} + \boldsymbol{ED}}{d_{E,tot}}$$
$$+ OpeCostPerDay * t_{E,port} + OpeCostPerDay * t_{E,sea} * \frac{d_{E,LL} + \boldsymbol{ED}}{d_{E,tot}} + CO_{2E,SL} * ETSPrice$$
$$* \frac{\boldsymbol{ED}}{d_{E,SL}} + DailyEarnings * 2 * \frac{\boldsymbol{ED}}{SOG * 24} + PortCost_E$$

where:

- *BaU* and *E* indices refer to the original case studied, for the compliance and evasion trips, respectively
- *LL* and *SL* indices refer to the long leg and short leg of the evasion trips, respectively, separated by the evasion port call.
- *tot* indice refers to the value of the variable for the entire trip, *sea* to its value for the part of the voyage spent at sea and *port* to its value for the part of the voyage spent in the port
- CO_2 are the CO_2 emissions (in tonnes) of the corresponding trip and part of the voyage
- *ETSPrice* is the ETS price level in €/tonne of CO_2
- *d* is the length (in nm) of the part of the trip indicated by its indices
- *t* is the duration (in days) of the part of the trip indicated by its indices
- *SOG* is the average speed-over-ground assumed for a given ship type and class (in knots)

The equation was then solved for ***ED*** to provide the results described in this report.

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