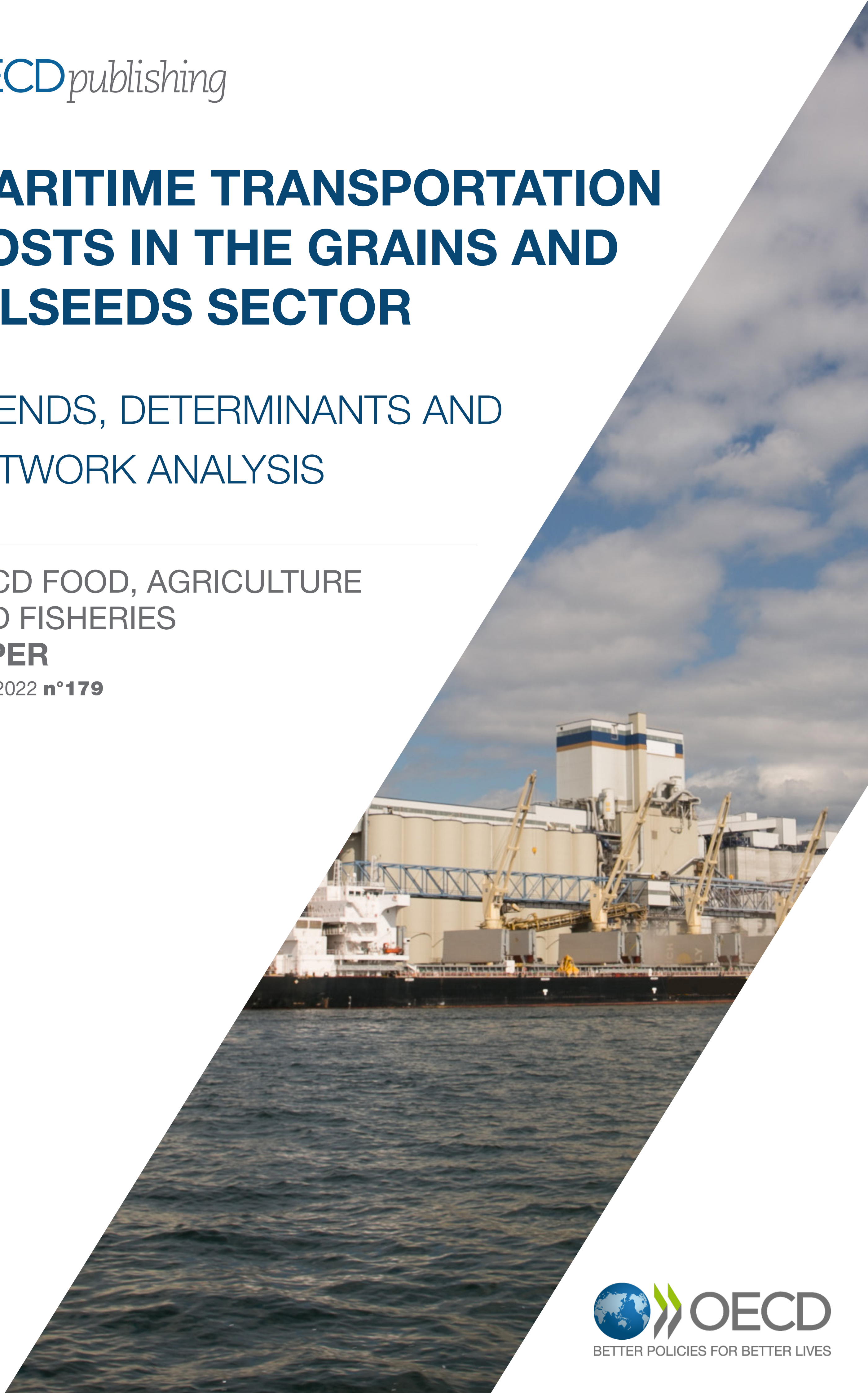
OECD*publishing*

MARITIME TRANSPORTATION COSTS IN THE GRAINS AND OILSEEDS SECTOR

TRENDS, DETERMINANTS AND NETWORK ANALYSIS



OECD FOOD, AGRICULTURE AND FISHERIES
PAPER
June 2022 **n°179**

OECD
BETTER POLICIES FOR BETTER LIVES

OECD TRADE AND AGRICULTURE DIRECTORATE

Maritime Transportation Costs in the Grains and Oilseeds Sector: Trends, Determinants and Network Analysis

Annelies Deuss, Federica Maggi, and Clara Frezal

More than 80% of global trade in grains and oilseeds occurs by maritime transport. This report provides an in-depth analysis of ocean freight rates during 2007-2021, examining their evolution, volatility, determinants, and how they influence port networks. Freight rates accounted on average for 11% of the cost and freight price, but this share ranges between 2% and 43%, demonstrating the potentially large impact of freight rates on consumer prices. Freight rates for grains and oilseeds are generally more volatile than their free-on-board prices. Regression analysis shows that a 10% increase in the distance between two ports is estimated to lead to a 2.5% increase in freight rates. It also demonstrates that freight costs for grains and oilseeds do not obey the iceberg formulation, which implies that they should be modelled as additive (constant costs per unit traded) rather than as multiplicative (iceberg) costs.

Key words: Freight rates, additive costs, iceberg, distance, ports

JEL codes: Q02, Q17, F14, R40, D85

Acknowledgements

The authors wish to thank Alexander Karavaytsev and Arnaud Petit from the International Grains Council (IGC) for providing data on freight rates and fob prices and for their valuable comments during the different stages of the project. The authors are grateful to Ben Shepherd (Developing Trade Consultants) for his contributions on the methodology. The authors thank Silvia Sorescu, Jane Korinek, Frank van Tongeren, Lee Ann Jackson, Edith Laget, Alonso Gonzalez Marentis (OECD), and Marco Fugazza (UNCTAD) for their input and suggestions, and Michèle Patterson for preparing this report for publication. The authors also wish to thank the members of the OECD Joint Working Party on Agriculture and Trade for their valuable feedback.

Table of Contents

Figures

Tables

Executive Summary

More than 80% of global trade in grains and oilseeds occurs by maritime transport. From mid-2020 onwards, ocean freight rates started to increase steadily, and by October 2021 reached their highest value in 13 years. Even though ocean freight rates are an important component of trade costs for grains and oilseeds, there are no in-depth studies available on this topic. A detailed analysis of maritime transportation costs is now possible thanks to a database on ocean freight rates developed by the International Grains Council (IGC). The dataset selected for this report covers over 300 bilateral routes at the port level (data for most countries is limited to one port) and captures around 70% of global trade flows of soybeans, wheat, sorghum, maize and barley.

This report takes three different approaches to examine maritime transportation costs in the grains and oilseeds sector. First, it analyses the evolution, volatility and importance of freight rates over time and across countries and commodities. The report focuses both on the long term (from 2007 until 2021) to compare the current situation with the period of the food price crisis of 2007-08, and on the short term (from mid-2019 until 2021). The distinction between the long- and short-term analysis is also driven by the database, which was expanded considerably from mid-2019 onwards. Second, the report evaluates the factors that determine freight rates and their relative importance using regression analysis. Finally, it uses network analysis to examine how freight rates shape the connections between ports that ship grains and oilseeds.

The analysis shows that freight rates for grains and oilseeds averaged at USD 35/t during the period January 2007-December 2021. However, freight rates display a high dispersion over time and across routes, even for a single commodity and exporting country, ranging between USD 7/t and USD 135/t during this period. Record values were reached during the food price crisis of 2007-08. Despite the surge in freight rates since mid-2020, the high average values recorded in October 2021 were only about two-thirds of those reached in June 2008. Volatility in freight rates was also at its highest during the food price crisis. For cargoes of HSS (heavy grains (wheat, durum), sorghum and soybeans), 2021 was the year with the third highest volatility in freight rates over the period 2007-2021.

This report also compares the volatility of freight rates with the volatility of free-on-board (fob) prices, and examines the role of freight rates in the final price paid by consumers, by calculating the share of freight rates in the cost and freight price. The analysis shows that freight rates for grains and oilseeds are in general more volatile than their export prices. For example, in 2007-08, the volatility of freight rates was almost 50% higher than the volatility of fob prices, and in 2021, freight rates were twice as volatile as fob prices. In addition, freight rates account on average for 11% of the cost and freight price of grains and oilseeds during the period January 2007-December 2021. This average hides large variations between trade routes and commodities over time as this share varies from 2% to 43%. The latter value clearly demonstrates the potentially large importance of freight rates in final prices.

The second part of the report investigates the determinants of freight rates. It focuses on the relative importance of three determinants: distance between ports, quantity traded and the fob price. Even though there are other determinants that would be interesting to examine, this is not possible because of lack of data (e.g. on supply and demand of bulk carriers) or insufficient variation in the data (e.g. oil prices do not vary between the import-export-commodity combinations). The regression analysis shows that:

- The distance over which grains and oilseeds are shipped is a crucial determinant of freight rates. More specifically, a 10% increase in the bilateral distance between two ports is estimated to lead to around a 2.5% increase in freight rates.
- The quantity shipped has no significant impact on the freight rates of grains and oilseeds. This means that there are no scale economies in shipping in this sector and that countries that ship large quantities do not exhibit significantly lower freight rates than countries shipping smaller quantities.

- The fob price has no significant effect on freight rates over the long term (2010-2021). This result changes when focusing on the recent time period (January 2019-October 2021), which was characterised by rising freight rates, high volatility and supply chain disruptions. During this recent period, a 10% increase in fob prices leads to a 0.8% decrease in freight rates. This result suggests that exporters facing increasing commodity prices tend to try to negotiate lower freight rates in efforts to stay competitive.
- Transportation costs in the grains and oilseeds sector do not obey the iceberg formulation. This implies that these costs should be modelled as additive (per unit) rather than as iceberg (constant percentage of the price per unit traded), which in turn has important welfare implications, since previous research has shown that modelling trade costs as additive rather than iceberg leads to higher welfare effects from reducing them.

The third part of the report examines how closely ports are connected based on the cost to move grains and oilseeds between them. The importance of ports in the network of grains and oilseeds shipments is calculated using the weighted centrality measure. This measure shows the importance of a port in the network by considering both the number of connections and the strength of the connections (a relatively lower freight rate between two ports is associated with a stronger connection). The analysis focuses on the years 2020 and 2021 because the database is more complete for these years. A key observation is that even though ports gain and lose some centrality between different points in time, the three or four most central ports for exports and for imports have remained the same in 2021 and 2022. More specifically, based on the routes covered in the IGC database, the ports of Baie-Comeau in Canada and of Santos in Brazil were the most central export ports in the network of HSS and maize, respectively. The most important port for barley exports was Kwinana in Australia in 2020 and Tilbury in the United Kingdom in 2021.

Whereas exports of grains and oilseeds are highly concentrated, imports are more dispersed. Yet, based on the IGC route coverage, the most important importing ports in the network of grains and oilseeds shipments also remained the same in 2020 and 2021. On the importing side, the ports of Cartagena in Spain and Alexandria in Egypt were the most important ports in the network of HSS shipments, while the ports of Rotterdam in the Netherlands and Genoa in Italy were the most central ports for maize. The port of Jeddah in Saudi Arabia was the most important port for barley.

The results of this report lead to two main conclusions. First, the role of freight rates in consumer prices reinforces the importance to have reliable, transparent and timely information on freight rates and on the components and determinants of freight rates. This is particularly relevant in light of the current elevated fuel prices. The IGC already provides synthesised information on freight rates to the Agricultural Market Information System (AMIS) Initiative. However, information on certain components and determinants (e.g. vessel hire costs, supply and demand of bulk carriers) are proprietary and hence more difficult to obtain. Second, a select number of ports play a crucial role in importing and exporting grains and oilseeds, which implies that any disruption or logistical problem can quickly escalate and have serious impacts on shipments and thus availability of commodities. This illustrates the importance of introducing measures that guarantee that shipments of grains and oilseeds can reach their destinations. Conversely, policy measures such as export restrictions, which are shown to contribute to rising and volatile food prices, should be avoided.

The report highlights the important role of the Russian Federation (hereafter "Russia") and Ukraine as key suppliers of grains and oilseeds to international markets. The analysis in this report covers the period until the end of 2021. Future research based on the methodology and data in this report could examine how the large scale aggression of Russia against Ukraine has affected freight rates and how trade patterns have adjusted to the crisis.

1. Introduction and motivation

Trade costs are a prominent part of the price consumers in importing countries pay for agro-food products. Trade costs are usually broken down into three main components: transport costs, policy costs, and distribution costs (Anderson and van Wincoop, 2004[1]). Each of these components varies over time, by commodity and between trading partners. Each of these components is also influenced by multiple factors. Transport costs, for example, depend on the type of transport, price of fuel, distance, size of the load, etc.

Because of data availability, most studies on trade costs take a generalized approach, focusing on the agricultural sector as a whole or using annual (or monthly) data. However, an in-depth analysis of trade costs would benefit from a sector-specific approach using granular information on each of the different components of trade costs, which is unfortunately not straightforward to obtain.

This report provides insights into a specific type of trade costs in the grains and oilseeds sector, namely maritime transport costs, which are significant as more than 80% of global trade in grains and oilseeds occurs by maritime transport (IGC, 2022[2]). A detailed analysis of these costs is now possible thanks to a rich dataset on daily ocean freight rates developed by the International Grains Council (IGC). The dataset covers over 300 bilateral routes at the port level and captures around 70% of global trade flows of soybeans, wheat, sorghum, maize and barley.

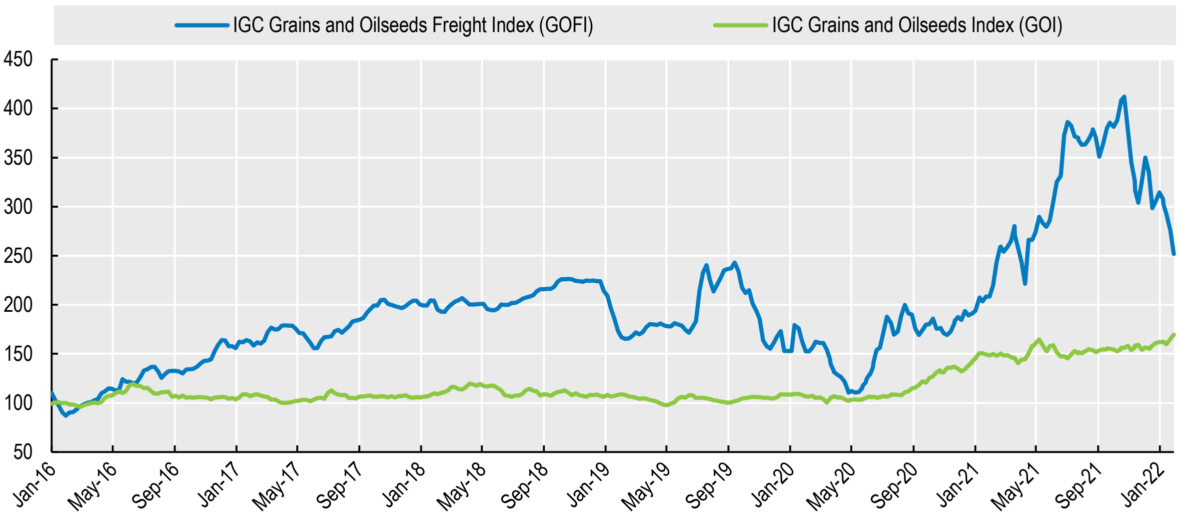
A study of maritime costs is particularly timely as the COVID-19 pandemic has drawn attention to the crucial role of the shipping sector in bringing goods to customers (Arriola, Kowalski and van Tongeren, 2021[3]). A focus on grains and oilseeds trade is relevant because international trade in these staple crops increased by around 70% in volume terms over the last decade (IGC, 2022[2]). Trade costs not only affect the prices of these goods in importing countries, but can also influence the domestic prices of bread, meat and other food products since imported grains and oilseeds are used as a feedstock or input in the food and feed sectors.

Freight rates display different trends than export prices. This is illustrated in Figure 1, which shows the evolution and volatility of the IGC Grains and Oilseeds Index (a measure for average export prices) and the IGC Grains and Oilseeds Freight Index (a measure for freight costs on major routes). The price index remained relatively stable during the last five years and then increased considerably from August 2020 onwards. The freight rate index appears to be more volatile over the entire period and rose dramatically over the last year, reaching a peak in October 2021 after which it started to decline. The recent surge in freight rates and the relatively higher volatility in freight rates compared to export prices add a level of uncertainty for importers, underscoring the need for a deeper understanding of freight rates.

These indexes mask differences between routes and commodities and the objective of this report is to examine those dynamics in much more detail. More specifically, using the IGC dataset, this report examines how freight costs have varied over time and across countries and commodities. Particular attention is given to the evolution of ocean freight since the outbreak of the COVID-19 pandemic. The report also investigates the determinants of freight rates and their relative importance. Finally, the report uses network analysis to examine which ports are the most important exporters and importers and whether this has changed over time.

This research aims to provide policy makers with useful insights into the evolution and determinants of trade costs for grains and oilseeds at a disaggregated level. Even though ocean freight rates are an important component of trade costs for grains and oilseeds, there are no recent and in-depth studies available on this topic. This is particularly relevant since the COVID-19 pandemic has sent shockwaves through global maritime transport and shipping costs have soared to multi-year high levels in recent months.

Figure 1. Evolution of the IGC Grains and Oilseeds Freight Index (GOFI) and IGC Grains and Oilseeds Index (GOI), January 2016 until January 2022 (January 2016=100)



Source: IGC (2022[2]).

2. Measuring maritime transportation costs

2.1. The Baltic Dry Index and the IGC Grains and Oilseeds Freight Index

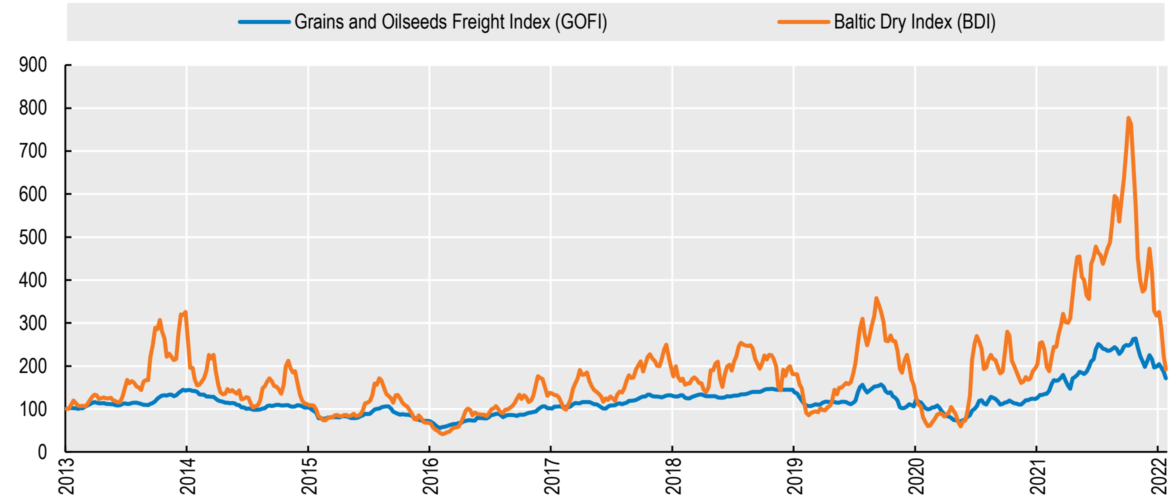
International shipping of goods can occur on different types of vessels. UNCTAD distinguishes five main vessel groupings: oil tankers, bulk carriers, general cargo ships, container ships and other ships (UNCTAD, 2020[4]). Grains and oilseeds are usually shipped in bulk carriers. Two commonly used indices to examine the cost of shipping these commodities are the Baltic Dry Index (BDI) and the IGC Grains and Oilseeds Freight Index (GOFI). Figure 2 shows the evolution of the BDI and GOFI since 2013. The evolution of these indicators varies significantly over time because they take into consideration different types of costs and different types of vessels.

The BDI is issued daily by the Baltic Exchange. The BDI is a composite indicator for vessel hire (time charter) costs across bulk carriers' main size categories (Capesize, Panamax and Supramax) and includes sub-indices for those three segments. Figure 3 illustrates the main commodities that are transported by these vessel types. From 1 March 2018 onwards, the Baltic Handysize sub-index was excluded from the BDI.

The GOFI is a trade-weighted composite measure of ocean freight costs for grains and oilseeds (maize, wheat, soybeans, barley, sorghum, and durum), issued by the International Grains Council on a daily basis (the quotations were weekly until 12 November 2019). The GOFI includes sub-indices for seven main origins (Argentina, Australia, Brazil, Black Sea, Canada, the European Union and the United States) and is constructed based on nominal voyage rates on selected major routes.

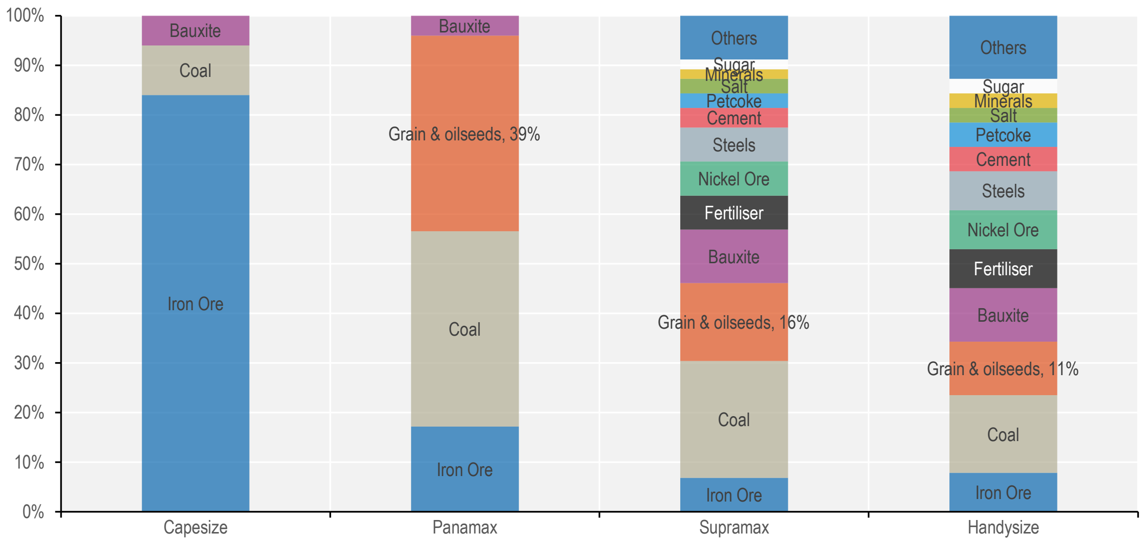
Voyage rates represent total freight costs for a route (expressed in USD per tonne of cargo) and include vessel hire (time charter) costs, fuel (bunker) costs, port, canal (if applicable), and other charges. Contrary to the BDI, the GOFI focuses on deliveries in Panamax, Supramax and Handysize segments, but does not cover Capesize vessels, as these latter vessels are mainly involved in the transportation of iron ore and heavy raw materials (Figure 3).

Figure 2. Evolution of the Baltic Dry Index (BDI) and the Grains and Oilseeds Freight Index (GOFI) from January 2013 until January 2022 (Jan 2013=100)



Source: IGC (2022[2]) and Baltic Exchange (2022[5]).

Figure 3. Bulk carriers: Main commodities carried by sector



Notes: Capesize are the largest bulk carriers and tankers with a deadweight tonnage (DWT) above 80,000. Panamax are carriers with a capacity of 60,000-80,000 DWT, mostly transporting coal, grains, oilseeds and other bulks. Supramax and Handysize have a capacity below 60 000 DWT. They account for the majority of the world's ocean vessels and can transport a wide variety of cargos, including grains and oilseeds.
Source: Howe Robinson Partners (2020[6]).

The BDI is a useful indicator to measure the demand and supply of dry bulk carriers. It indirectly also provides an indicator of the global demand and supply of the commodities that are shipped in bulk. However, when examining grains and oilseeds trade, the GOFI is more suitable than the BDI because the GOFI incorporates the carriers that actually transport grains and oilseeds, whereas the BDI considers capesize vessels which mostly transport iron ore and heavy raw materials and does not consider handysize segments. Furthermore, the BDI only includes vessel hire costs while the GOFI includes several types of costs, thereby providing a more complete picture of transportation costs.

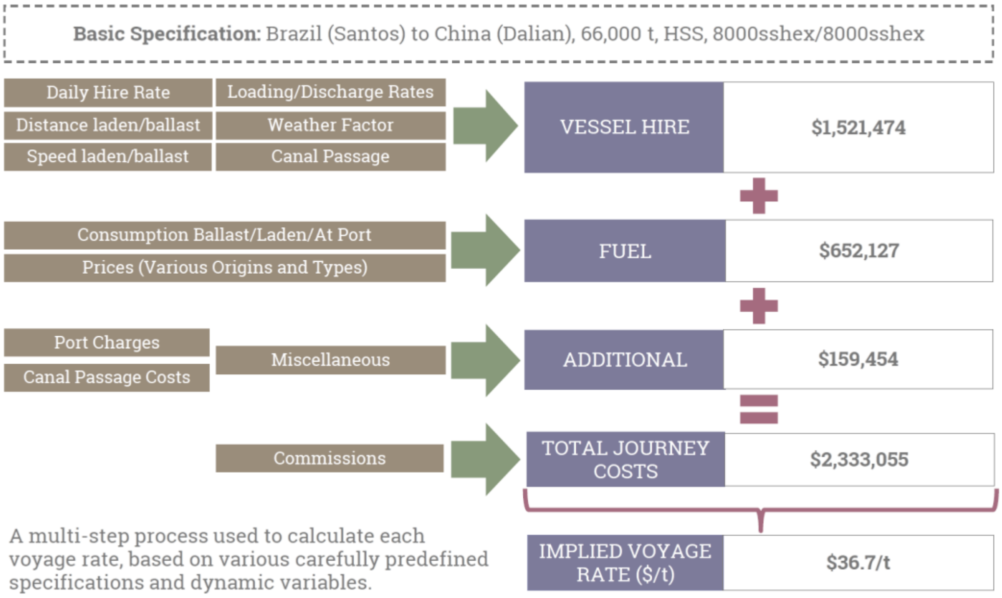
The GOFI and its seven sub-indices are suitable to examine overall trends in transportation costs. These sub-indices are constructed using detailed information on freight rates for specific trade routes and cargo, which in turn provide the rich information base used for the granular analysis of the transportation costs in the grain and oilseeds sector in this report.

2.2. The IGC model-based ocean freight rates

In May 2018, IGC launched its dry bulk freight model. Prior to that date, freight rates were assessed weekly by IGC analysts with inputs from an external advisor and information from industry sources. Under the dry bulk freight model, daily freight rates are calculated automatically, incorporating several parameters such as fixed route parameters (including distances, sizes, loading and discharge), daily market variables (including hire rates and bunker (fuel) prices), and comprehensive vessel specifications (including speed and fuel consumption).

A major advantage of the IGC dry bulk freight model is that it uses a uniform methodology to calculate voyage rates. Figure 4 illustrates with an example the multi-step process used to calculate the voyage rate for shipping HSS (heavy grains (wheat, durum), sorghum and soybeans) from Brazil (Santos) to the People's Republic of China (hereafter "China'') (Dalian).

Figure 4. Example of calculation methodology used in the IGC dry bulk freight model



Source: International Grains Council (2019[7]).

3. Evolution, patterns and importance of maritime freight rates in the grains and oilseeds sector

This section starts with a description of the IGC datasets on freight rates and on free-on-board (fob) prices and explains how the data are aggregated and represented in the figures and analysis. The section then analyses the dispersion, evolution and volatility of freight rates by cargo and by exporter over time. After an overview of the evolution and volatility of fob prices, the datasets on freight rates and fob prices are combined to examine how the share of freight rates in the cost and freight (C&F) price of grains and oilseeds has changed over time and between exporters.

3.1. Datasets

The IGC freight rate database collects information on maritime freight rates between exporters and importers of grains and oilseeds from 2007 onwards. With the introduction of the bulk freight model in 2018, the IGC freight rate database expanded in several dimensions. First, the commodity coverage was extended: in addition to HSS and barley, the model also calculates freight rates for maize[1] from 2019 onwards. Second, the geographical coverage increased: the number of destinations increased from 30 to 53 countries, and the number of routes from 104 to over 300. Third, the frequency of reporting changed from weekly to daily from July 2019 onwards.

Table 1 lists the number of observations and the number of routes by cargo and by year currently available in the IGC freight rate database. The number of annual observations increased almost eightfold between 2018 and 2019 because of the introduction of the freight rate model. The observations more than doubled between 2019 and 2020 because the frequency of reporting changed from weekly to daily in July 2019. This report considers information on freight rates until 31 December 2021.[2]

Table 1. IGC freight rate database: Number of observations and routes by cargo and year

	Number of observations				Number of routes			
	Barley	HSS	Maize	Total	Barley	HSS	Maize	Total
2007	561	4743	0	5304	11	93	0	104
2008	583	4923	0	5506	11	93	0	104
2009	572	4836	0	5408	11	93	0	104
2010	561	4743	0	5304	11	93	0	104
2011	572	4836	0	5408	11	93	0	104
2012	561	4742	0	5303	11	93	0	104
2013	583	4928	0	5511	11	93	0	104
2014	572	4835	0	5407	11	93	0	104
2015	572	4888	0	5460	11	97	0	108
2016	572	4942	0	5514	11	97	0	108
2017	572	4940	0	5512	11	95	0	106
2018	572	4943	0	5515	11	96	0	107
2019	2111	29346	10350	41807	14	195	69	278
2020	6656	57076	21648	85380	26	226	87	339
2021	6734	58534	22533	87801	26	226	87	339

Notes: HSS stands for heavy grains (wheat, durum), sorghum and soybeans.
Source: IGC (2022[2]).

The routes are identified at the level of ports within the exporting and importing countries. Exports of HSS, barley and maize are concentrated in a few countries and the IGC freight database focuses on those large exporters. Table 2 indicates, for each cargo, the main exporters included in the database. With the exception of Brazil and the United States, only one port is covered per exporter.[3] Freight rates for Brazil are available for the ports Santos and Itaqui and for the United States for the ports New Orleans (Gulf) and Tacoma (Pacific Northwest).

[1] From 2019, the IGC database also started recording freight rates for rice. Rice is not included in this analysis because i) there are only few observations for rice in the database, and ii) rice can also be shipped in containers.

[2] The IGC database keeps expanding: by March 2022, there were 404 quoted rates, including rice. With these latest additions, the database covers close to 80% of global trade flows.

[3] The IGC freight database covers one port per importer, with the exception of Oman where information is available for two ports (Port Sultan Qaboos and Salalah) from 2020 onwards.

Even though information on freight rates is collected for only a small set of exporting countries for the three types of cargo, this list of countries covers the majority of exports in grains and oilseeds. Table 2 lists the exporters covered in the database and indicates from which year data is available. In 2020, the exporters in Table 2 were responsible for 75% of global barley trade and for over 90% of global HSS and maize trade (IGC, 2022[2]).

Table 2. IGC freight rate database: Data availability by exporter and cargo

	Barley	HSS	Maize
Argentina		2007	2019
Australia	2007	2007	
Brazil		2007	2019
Canada		2007	
France	2007	2007	2020
Germany		2020	
Romania		2020	2020
Russia	2007	2007	
Ukraine	2020	2019	2019
United Kingdom	2020	2020	
United States	2007	2007	2019

Notes: HSS stands for heavy grains (wheat, durum), sorghum and soybeans.
Source: IGC (2022[2]).

The IGC also collects information on free-on-board (fob) prices.[4] This database provides daily information at the country level for different commodities, including barley, maize, sorghum, soybeans and wheat. For some countries, more than one series per commodity is available because quotes are collected for more than one port, for more than one specification of the commodity (e.g. wheat with a protein content of 10.5% or 12%), or both. Table 3 indicates, by commodity, the exporters included in the IGC fob database.[5]

Table 3. IGC fob database: List of exporters by commodity

	Barley	Maize	Sorghum	Soybean	Wheat
Argentina		x	x	x	x
Australia	x		x		x
Brazil		x		x	
Canada					x
France	x	x			x
Germany					x
Romania					x
Russia	x				x
Ukraine		x		x	x
United Kingdom					x
United States		x	x	x	x

Source: IGC (2022[2]).

[4] The IGC collects information on fob prices from January 2000 onwards, but for this report only the prices from January 2007 are considered.

[5] The list of importing countries, by cargo, can be found in Table A C.1.

To analyse and represent the data on freight rates and fob prices in a consistent way, the data are reorganised following some specific rules. First, even though data are available at the port level, the analysis is done at the country level because there are only a few countries with multiple ports and because it is more straightforward to interpret and present the results. For the exporters in the freight database, there are only two countries with two ports, namely Brazil and the United States. In the case of Brazil, the port of Santos was selected because there are significantly more observations for this port than for Itaqui. For the United States, the port of Tacoma was used for barley because the database only has freight rates for this port. For HSS and maize freight rates in the United States, the port of New Orleans was selected because larger volumes are shipped from this port than from Tacoma.[6] There is only one importer with two ports available in the freight database, namely Oman. Since the number of observations for both ports are the same, the freight rates are averaged for this country.

In the fob database, multiple series can be reported for a specific commodity in a certain country. In order to merge and compare the price data with the freight rates, the information in the fob database was reorganised to obtain one price per commodity per country. When the fob database contains information for more than one port, only the port that is available in the freight database was selected. If there is more than one specification for a commodity in a certain country, an average fob price was calculated.

Second, two periods of analysis are used since the commodity coverage, the number of routes, and the frequency of reporting for freight rates increased from 2019 onwards. Analysis over the long term covers the period from 1 January 2007 until 31 December 2021 and uses weekly data as daily data are only available from July 2019 onwards. Analysis over the short term spans the period from 1 July 2019 until 31 December 2021 and uses daily data.[7]

Third, when looking at the evolution of freight rates over time, both in the long and the short term, we only consider trade routes and commodities (i.e. exporter-importer- commodity/cargo triplets) for which the database contains complete data across time. This implies, for example, that the analysis of HSS freight rates in Ukraine is only conducted for the short term, as data are only available from 2019 onwards.[8] Annex D lists the number of routes included in the long-term and short-term analysis by exporter and by cargo.

Finally, the coefficient of variation (CV) is used to measure volatility in freight rates and fob prices. The CV, which is the standard deviation divided by the mean, is selected because it does not depend on the unit of measurement and can be compared between different variables.

3.2. Dispersion, evolution and volatility of freight rates

3.2.1. Dispersion of freight rates

A first way to examine the IGC data is by presenting the dispersion of freight rates by cargo and exporting country over the long term and short term. Figure 5 uses boxplots to show the dispersion of freight rates by exporter for barley and HSS over the long term (i.e. between January 2007 and December 2021). Freight rates for barley and HSS averaged at USD 33/t and USD 35/t, respectively, over this period. However, there is considerable variation in freight rates around the mean, even for a single exporting country.

For HSS cargo originating from Canada, for instance, the mean freight rate is USD 36/t, the median is USD 32/t, 50% of the observations are comprised between USD 24/t and USD 45/t, with freight rates ranging from USD 7/t (minimum) to USD 135/t (maximum) (Figure 5, right panel). For most exporters the maximum value was reached during the food price crisis of 2007-08 (Section 3.2.2).

[6] In 2017, 37% of US agricultural exports were shipped from New Orleans and 4% from Tacoma (USDA, 2019[37])

[7] Even though the analysis for the short term is done at the daily level, the figures show weekly averages for representation purposes.

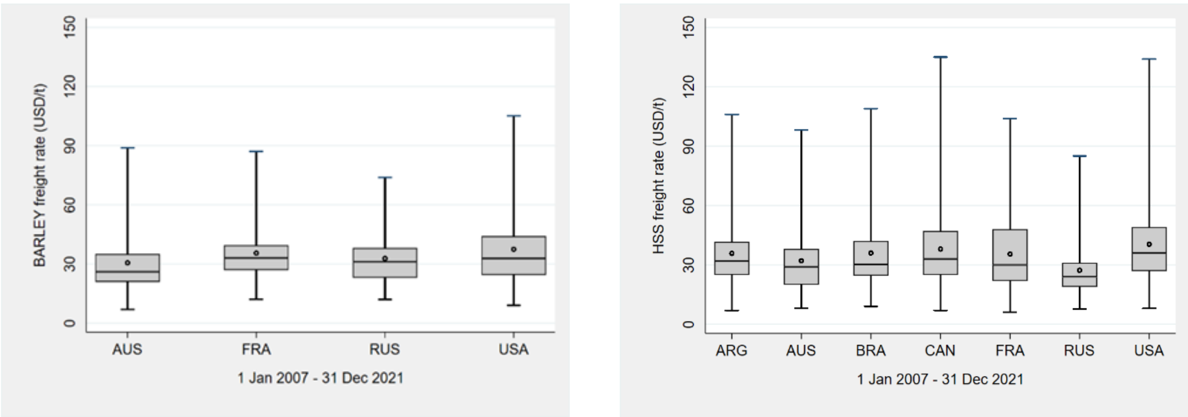
[8] Following this rule, some countries/regions (e.g. Germany, the United Kingdom, and Romania) are not considered in the analysis as there are no complete data series for the long or the short term.

Figure 6 focuses on the shorter term and shows the dispersion of freight rates by exporter for barley, HSS and maize between July 2019 and December 2021. As mentioned above, figures for the short term include more routes as the introduction of the freight rate model in 2019 expanded the database's coverage of exporters, importers, and cargo (i.e. maize is also included). In addition, the frequency of reporting increased from weekly to daily from July 2019 onwards. Figure 6 illustrates that there is also a high dispersion of freight rates in recent years. Freight rates for maize from Argentina, for instance, averaged at USD 44/t over this period; ranging from USD 13/t (minimum) to USD 104/t (maximum).

There are many possible reasons behind the observed dispersion in freight rates, including differences in geographical distance between the exporter and the importers. Over the period January 2007 to December 2021, the average shipping cost of HSS from Australia to Korea, for instance, was USD 23/t, against USD 47/t from Australia to Algeria. The determinants of freight rates are examined econometrically in Section 4.

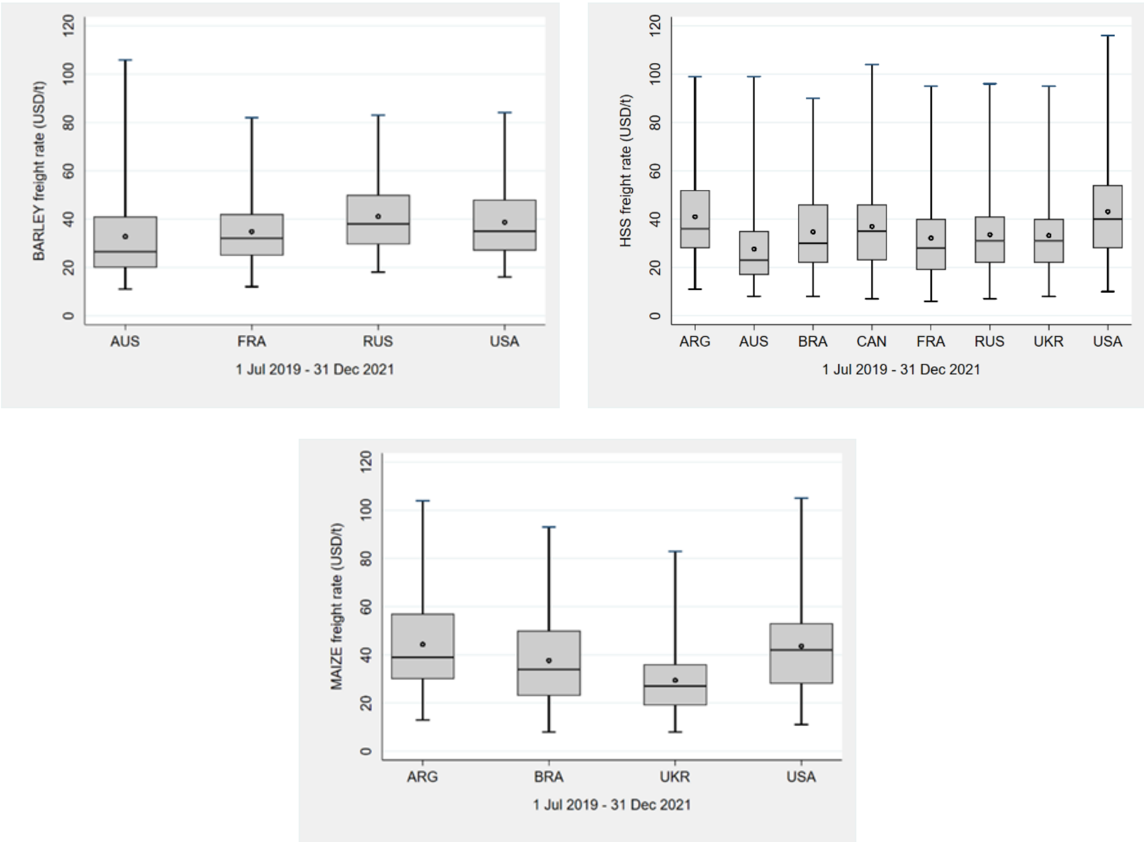
Figures 5 and 6 show the dispersions of freight rates by cargo and by exporter. However, the dispersion of freight rates is not strictly comparable between exporters or between cargoes for several reasons, including differences in distance between the exporter and the importers, differences in the number of routes covered, and differences in the number of observations available in the IGC database. The relatively lower dispersion of HSS freight rates from Russia (Figure 5, right panel), for instance, is partly due to the fact that only four HSS trade routes are covered for Russia, compared to more than 20 routes for the United States.

Figure 5. Dispersion of freight rates by cargo and exporter over the long term (January 2007 – December 2021)



Note: These boxplots have several components. The grey box indicates the range where 50% of the observations are situated; the lower bar of the box is the first quartile (Q1/25th percentile), the middle bar is the median (Q2/50th percentile), and the top bar is the third quartile (Q3/75th percentile). The circle is the mean. The maximum (minimum) value is situated at the end of the top (bottom) whisker.
Source: Authors' calculations based on IGC (2022[2]).

Figure 6. Dispersion of freight rates by cargo and exporter over the short term (July 2019 – December 2021)



Note: These boxplots have several components. The grey box indicates the range where 50% of the observations are situated; the lower bar of the box is the first quartile (Q1/25th percentile), the middle bar is the median (Q2/50th percentile), and the top bar is the third quartile (Q3/75th percentile). The circle is the mean. The maximum (minimum) value is situated at the end of the top (bottom) whisker.
Source: Authors' calculations based on IGC (2022[2])

3.2.2. Evolution of freight rates

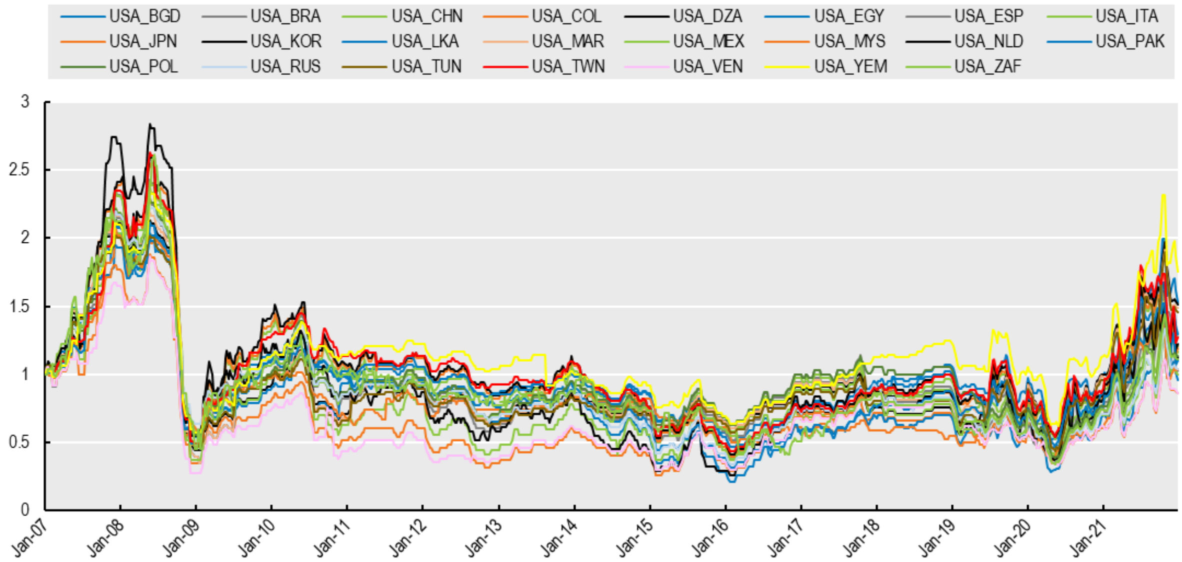
It is interesting to examine how freight rates have changed over time for the available exporter/importer/cargo combinations (hereafter referred to as "triplets"). Figure 7 shows the evolution of freight rates for HSS between January 2007 and December 2021 for every route originating from the United States. The United States is selected as an example because the database contains the most HSS routes for this country. Similar figures for other triplets are presented in Annex A. Overall, the freight rates for the available trade routes and cargoes (i.e. HSS, barley and maize) show similar patterns over time.

For the years covered by the IGC dataset, two periods are particularly noteworthy. First, freight rates increased significantly between January 2007 and June 2008 and reached record values during this period, after which they dropped dramatically by January 2009. The average freight rate for HSS and barley[9], for example, more than doubled between January 2007 and June 2008 (from USD 42/t to USD 86/t) and then plummeted to USD 20/t in January 2009. Freight rates recovered after January 2009, but never returned to their previous peaks.

[9] The average freight rate is a simple average calculated using the set of triplets for which the IGC database has complete data series over the long term (January 2007-December 2021); it therefore only considers HSS and barley and a selected set of exporters and importers.

Second, the period coinciding with the COVID-19 pandemic is also of particular interest. Freight rates declined during the first months of the COVID-19 outbreak until May 2020, and then rose steadily to maximum levels for the last decade. The average freight rate for HSS and barley, for example, reached a historical low in May 2020 (USD 16/t) and tripled by December 2021 (USD 49/t). Despite the strong increase in freight rates since the second half of 2020, they are still well below the 2008 record values, with the high average values recorded in October 2021 being only about two-thirds of those reached in June 2008.

Figure 7. Long-term evolution of freight rates for HSS cargoes originating from the United States, January 2007 – December 2021 (January 2007=1)



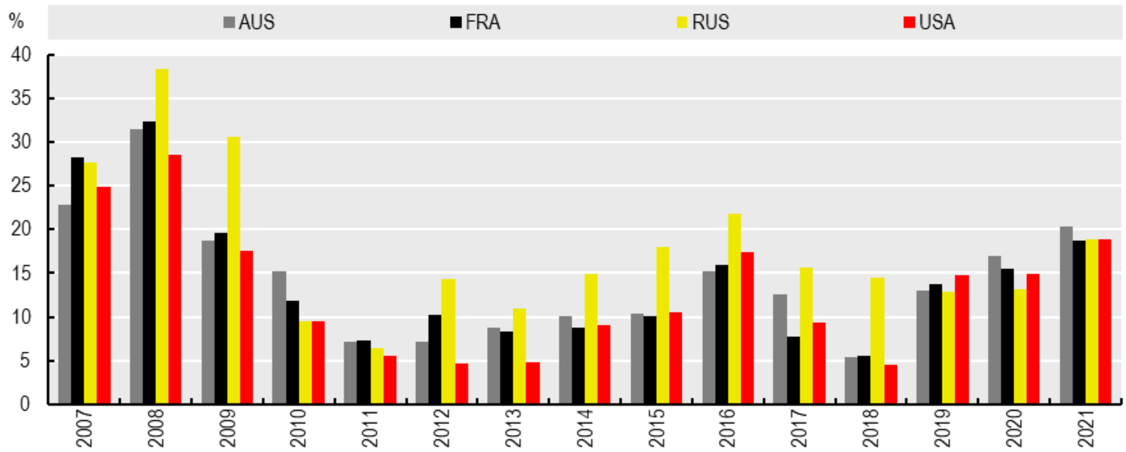
Source: Authors' calculations based on IGC (2022[2]).

3.2.3. Volatility of freight rates

The volatility of freight rates is presented[10] using the CV. Figures 8 and 9 show the CV for freight rates by year and exporter from 2007 to 2021 for barley and HSS, respectively. The period of the food price crisis is characterised by high volatility of freight rates. For both barley and HSS, freight rates were most volatile in 2007 and 2008, with the CV averaging 25% in 2007 and 33% in 2008, across all exporters. Volatility during the COVID-19 period was lower than during the food price crisis. In 2021, freight rates for HSS reached their third highest CV during the period under consideration (averaging 21% across all exporters), whereas freight rates for barley averaged 19% across all exporters (the fourth highest CV for barley during the period).

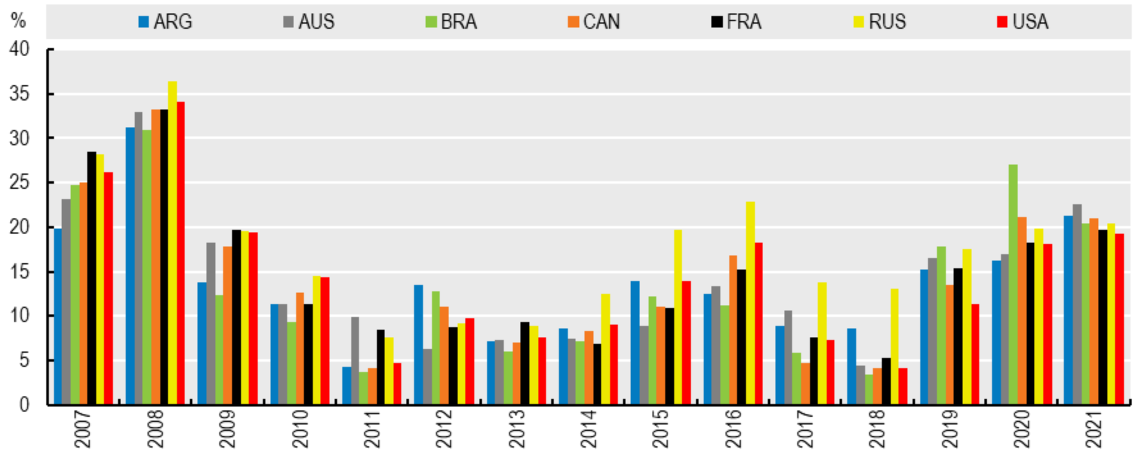
[10] The purpose of these figures is to examine overall trends by exporter and commodity. It is beyond the scope of this report to study the reasons behind the trends in volatility.

Figure 8. Coefficient of variation for freight rates by year and exporter, BARLEY (2007-2021)



Source: Authors' calculations based on IGC (2022[2]).

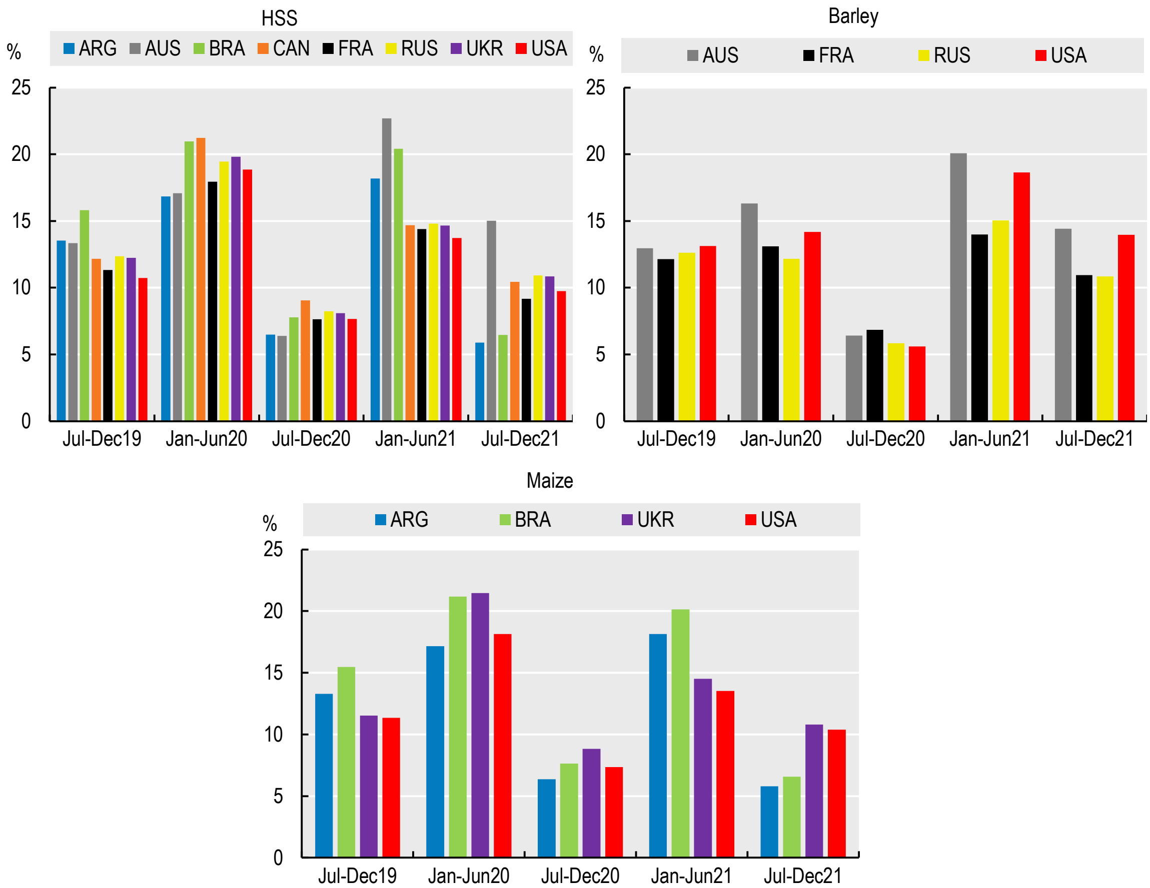
Figure 9. Coefficient of variation for freight rates by year and exporter, HSS (2007-2021)



Source: Authors' calculations based on IGC (2022[2]).

The volatility of freight rates is also examined over the short term, taking advantage of the richer database from July 2019 onwards and hence providing insight for the COVID-19 period. Figure 10 shows the CV for freight rates by exporter for HSS, barley and maize for six-month periods from July 2019 until December 2021. During this period, volatility was at its lowest during the second half of 2020, whereas it was at its highest during the first six months of 2020 and 2021. The CV for the first six months of 2020 and 2021 averaged 17% across all exporters and cargoes, while it averaged only 7% for the second half of 2020.

Figure 10. Coefficient of variation for freight rates by exporter for 6-month periods (01/07/2019-31/12/2021)



Source: Authors' calculations based on IGC (2022[2])

3.3. Evolution and volatility of export prices

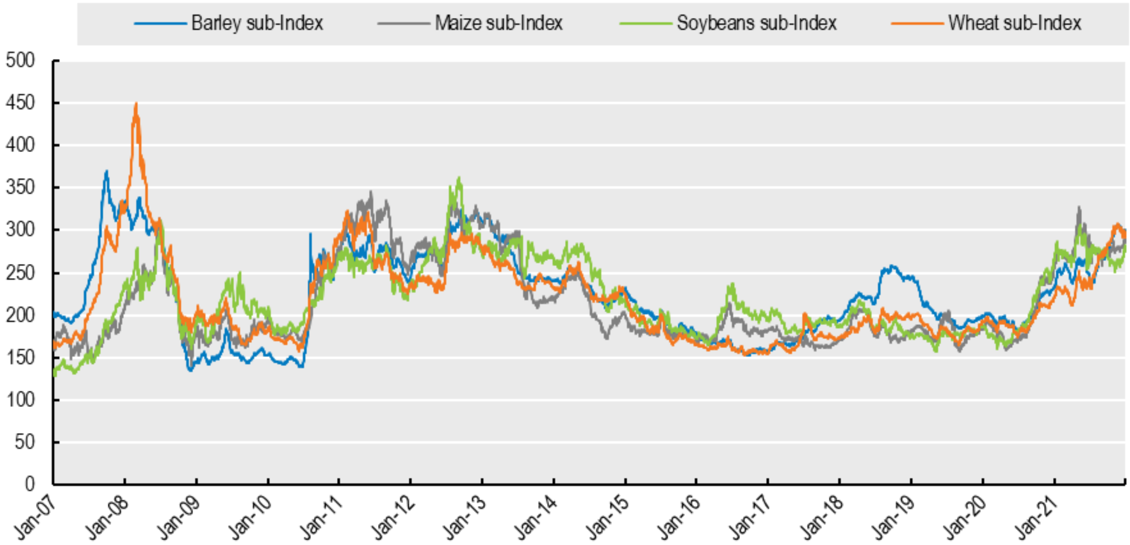
Before examining the importance of freight rates in the C&F price (calculated as the fob price plus the freight rate) in Section 3.4, it is useful to identify the main trends in export prices. A detailed analysis of these trends and their causes is beyond the scope of this report. Instead, this section provides a general overview of the evolution of export prices and compares the volatility of fob prices with that of freight rates.

The fob price (also called export price in this report) is the price of the good at the border of the exporting country; it includes the value of the good, the transport and distribution services up to the border, the taxes minus the subsidies (INSEE, 2021[8]).

3.3.1. Evolution of export prices

Figure 11 illustrates the evolution of export prices using the IGC sub-indexes for barley, maize, soybeans and wheat between January 2007 and December 2021. Grain and oilseed prices surged in 2007-2008 and 2010-2013, due to a combination of factors, including poor harvests in several key producers, low cereal stocks, rising oil prices, export restrictions and the depreciation of the US dollar. A detailed overview of the causes of these price increases can be found in FAO (2017[9]). After the food price crises, grains and oilseeds prices slowly came down and remained relatively stable for several years. Following the COVID-19 outbreak, prices stayed on trend during the first half of 2020, but started increasing from mid-2020 onwards, and in 2021, they reached levels close to the peaks of 2010-2013.

Figure 11. IGC price indices for barley, maize, soybeans and wheat from 1 January 2007 until 31 December 2021 (Jan 2000=100)



Note: The sub-indices for barley, maize, soybeans and wheat are based on daily price quotations from several official and trade sources.
Source: Authors' calculations based on IGC (2022[2]).

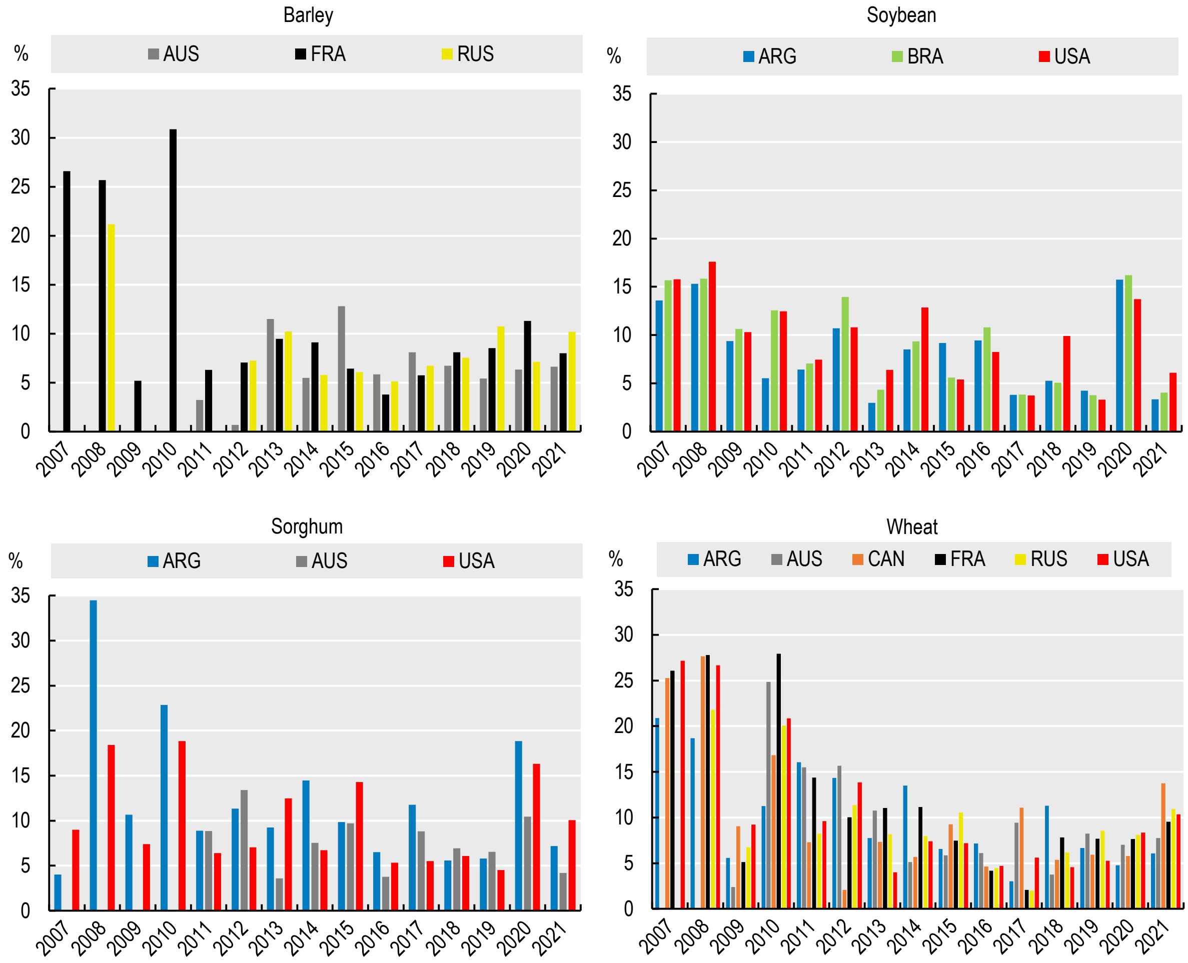
3.3.2. Volatility of export prices

The volatility of export prices is analysed by calculating the CV for the fob prices in the IGC fob database. As explained in Section 3.1, the information in the IGC fob database was reorganised to match the information in the IGC freight database.

Figure 12 shows the CV for fob prices by year and exporter from 2007 to 2021 for barley, soybean, sorghum, and wheat. As for freight rates, the period of the food price crisis is associated with high volatility. For most commodities, the highest CV for export prices are reached in 2007 and 2008. For barley and wheat, for instance, the CV for fob prices in 2007-08 averaged at 25% across all exporters. For all commodities except soybean, 2010 is also a year of high volatility with the CV for barley, sorghum and wheat fob prices averaging at 31%, 21% and 20%, respectively, across all exporters.

Volatility in recent years appears relatively lower, except for soybean for which the CV in 2020 was as high as during 2007-08 (15%). For sorghum, 2020 is the year with the third highest CV (after 2008 and 2010), averaging at 15% across all exporters.

Figure 12. Coefficient of variation for fob prices by year and exporter (2007-2021)

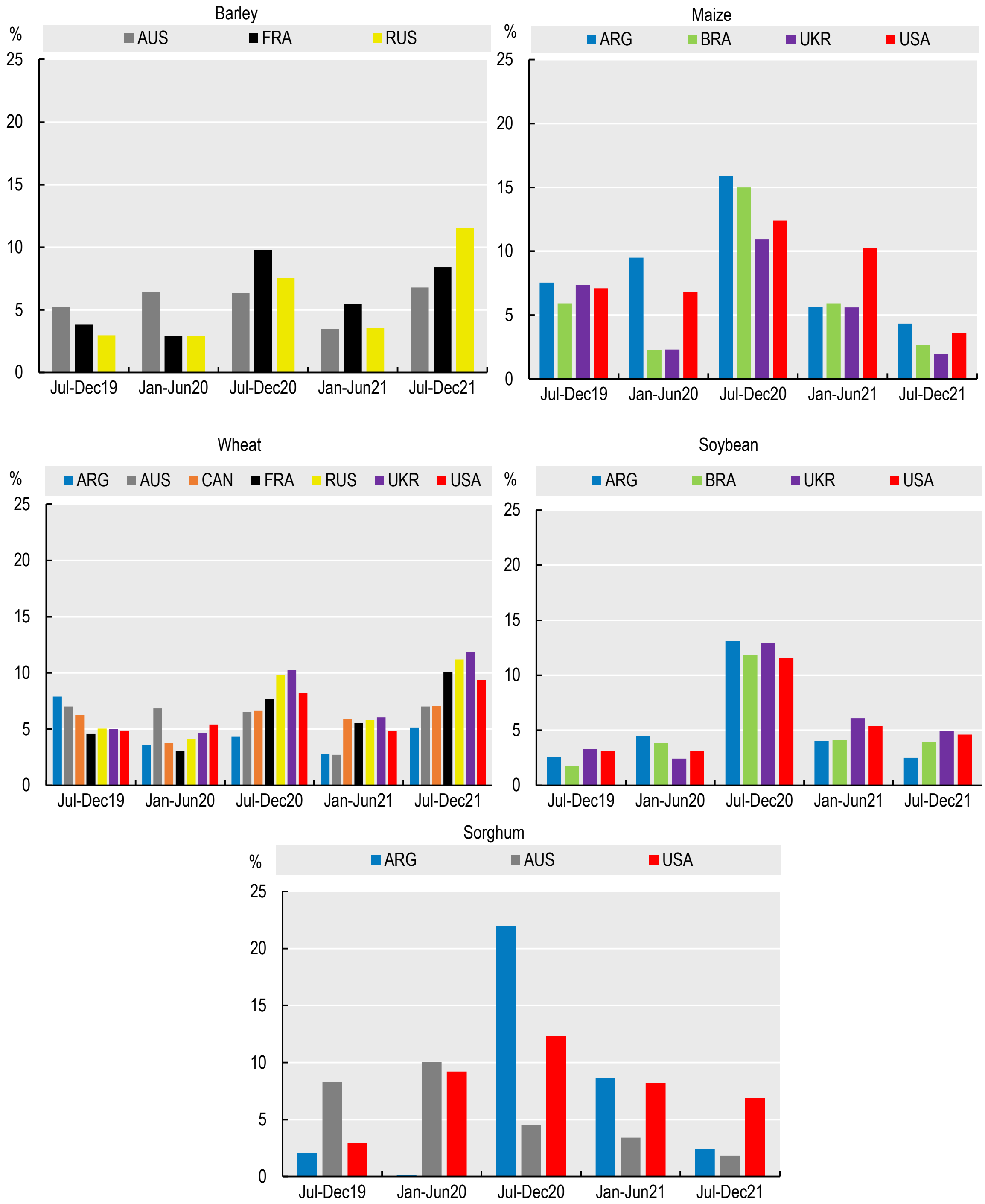


Source: Authors' calculations based on IGC (2022[2]).

Volatility of fob prices was also examined over the short term. Figure 13 shows the CV for fob prices by exporter for barley, maize, soybean, sorghum and wheat for six-month periods from July 2019 to December 2021. The second half of 2020 is the period with the highest volatility in export prices for maize, soybean and sorghum, with the CV across all exporters averaging 14%, 12% and 13%, respectively. The volatility of barley and wheat fob prices during this period reaches its highest value in the second half of 2021, at an average of 9% across all exporters.

Using the CV as a measure of volatility allows comparison of the volatility of freight rates and fob prices. Overall, the volatility of freight rates is higher than the volatility of export prices. For instance, the CV for freight rates for the period 2007-2008 averaged at 29% across all exporters and commodities, against 20% for fob prices. Volatility of freight rates was also higher than volatility of export prices during the COVID-19 pandemic. The CV for freight rates averaged at 13% in 2020 and 2021 across all exporters and commodities, against 8% in 2020 and 6% in 2021 for fob prices. The only exception is the second half of 2020, which is characterised by high volatility in fob prices and low volatility in freight rates.

Figure 13. Coefficient of variation for fob prices by exporter for 6-month periods (01/07/2019-31/12/2021)



Source: Authors' calculations based on IGC (2022[2]).

3.4. Share of freight rates in cost and freight (C&F) prices

To gain insights into the importance of maritime freight rates in the C&F price of grains and oilseeds the IGC databases on freight rates and fob prices were merged by date, exporter and commodity as explained in Section 3.1. The C&F price of each commodity, defined as the sum of the freight rate and the fob price, was then computed (for a given date and trade route). Finally, the freight rate was divided by the C&F price to obtain the share of freight rate in C&F price.

3.4.1. Dispersion of the share of freight rates in C&F prices

A first way to examine data on the share of freight rates in the C&F price is by looking at its dispersion over a selected period. Between January 2007 and December 2021, freight rates accounted on average for 11% of the C&F price of grains and oilseeds; but this share varies considerably over time, ranging from 2% to 43%.[11] This variation confirms that maritime transportation costs can be a significant part of the price paid by consumers in importing countries and highlights the importance of this report.

Figure 14 uses boxplots to show the dispersion of this share by exporter for barley, soybean, sorghum and wheat between January 2007 and December 2021. This figure illustrates that there is substantial dispersion in the share of freight rates in C&F price even when looking at a single commodity and exporting country. For sorghum shipped from the United States, for example, the average share of freight rate in the C&F price is 14%, the median is 13%, 50% of the observations are between 10% and 18%, and the share ranges from 3% (minimum) to 39% (maximum) (Figure 14, bottom left panel).

Moreover, during recent years, there is a high dispersion in the share of freight rate in the C&F price. Between July 2019 and December 2021, the share of freight rate in the C&F price of grains and oilseeds averaged at 12%; ranging from 2% to 32%.[12] These shares again vary by commodity and exporter. Figure 15 shows the dispersion of this share by exporter for barley, maize, soybean, sorghum and wheat between July 2019 and December 2021. For maize shipped from Argentina, for instance, this share averaged at 17% over this period, and ranged from 8 % (minimum) to 32% (maximum) (Figure 15, upper right panel).

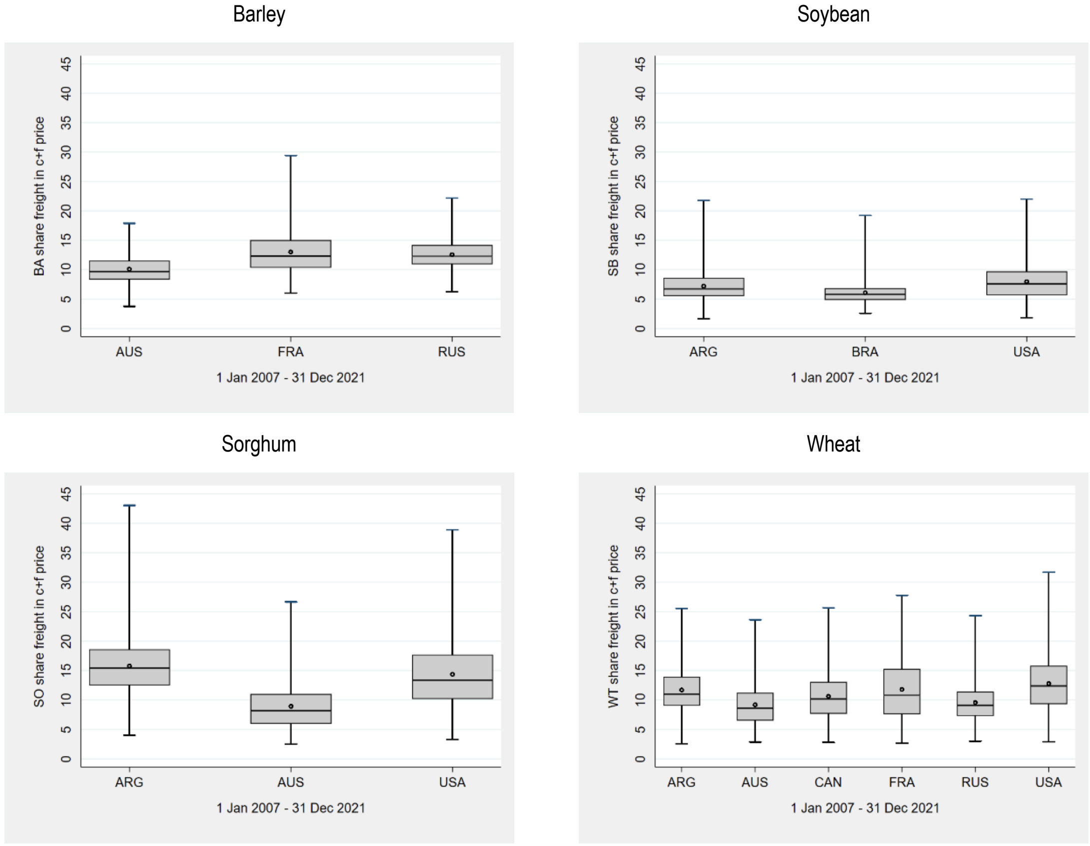
Figure 14 and Figure 15 highlight the relative freight advantages by cargo. Ukraine has a relative freight advantage for maize, Australia for wheat, sorghum and barley, and Brazil and Ukraine for soybean.

---

[11] The average share of freight rate in C&F price is a simple average calculated using the set of triplets for which the IGC database has complete data series over the long term (January 2007-December 2021); it therefore only considers barley, soybean, sorghum and wheat and a select set of exporters and importers.

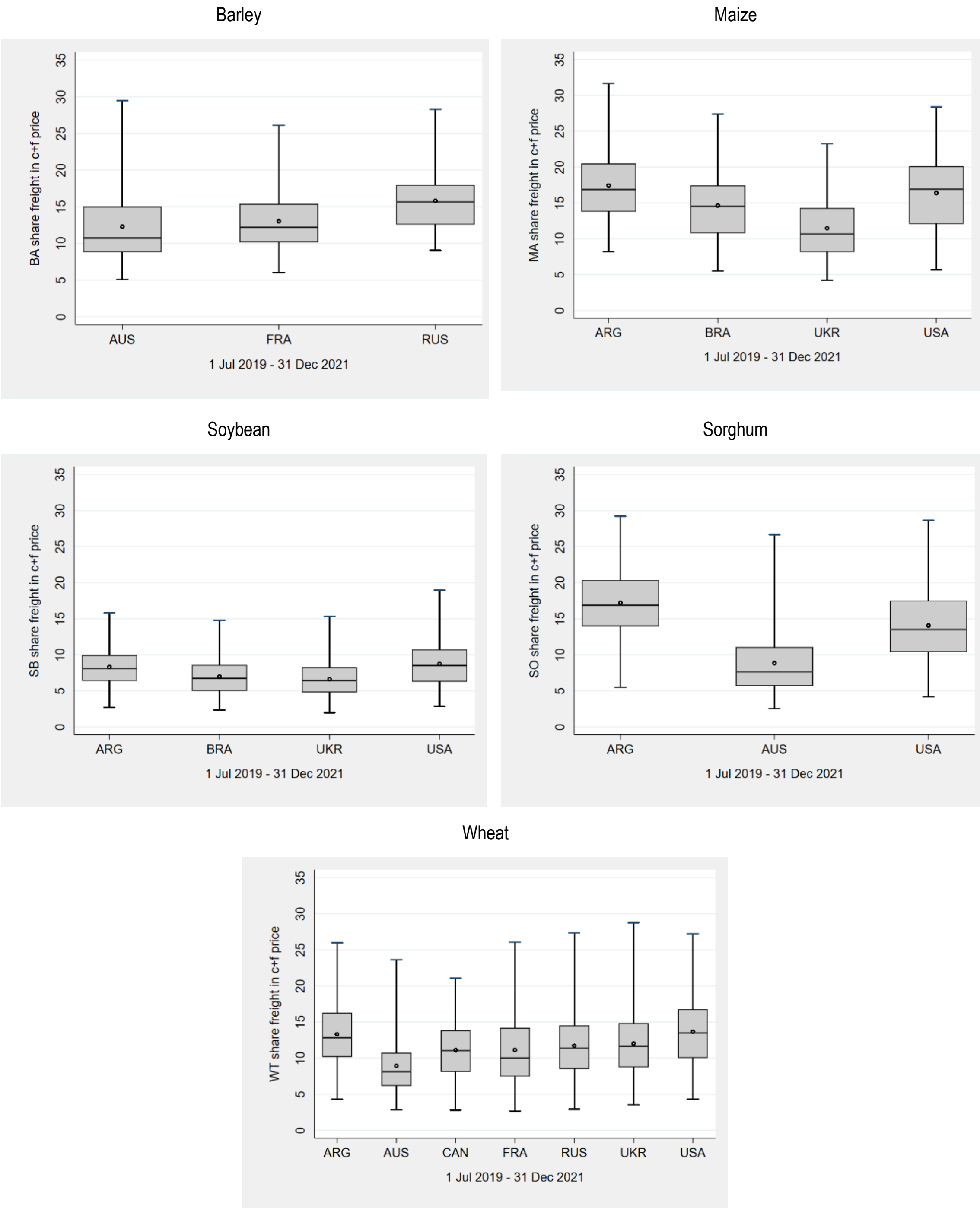
[12] The average share of freight rate in C&F price is a simple average calculated using the set of triplets for which the IGC database has complete data series over the short term (July 2019-December 2021); it therefore only considers a selected set of exporters and importers but covers all commodities (including maize).

Figure 14. Dispersion of the share of freight rate in C&F price by commodity and exporter (January 2007 – December 2021)



Note: These boxplots have several components. The grey box indicates the range where 50% of the observations are situated; the lower bar of the box is the first quartile (Q1/25th percentile), the middle bar is the median (Q2/50th percentile), and the top bar is the third quartile (Q3/75th percentile). The circle is the mean. The maximum (minimum) value is situated at the end of the top (bottom) whisker.
Source: Authors' calculations based on IGC (2022[2]).

Figure 15. Dispersion of the share of freight rate in C&F price by commodity and exporter (July 2019 – December 2021)



Note: These boxplots have several components. The grey box indicates the range where 50% of the observations are situated; the lower bar of the box is the first quartile (Q1/25th percentile), the middle bar is the median (Q2/50th percentile), and the top bar is the third quartile (Q3/75th percentile). The circle is the mean. The maximum (minimum) value is situated at the end of the top (bottom) whisker.
Source: Authors' calculations based on IGC (2022[2]).

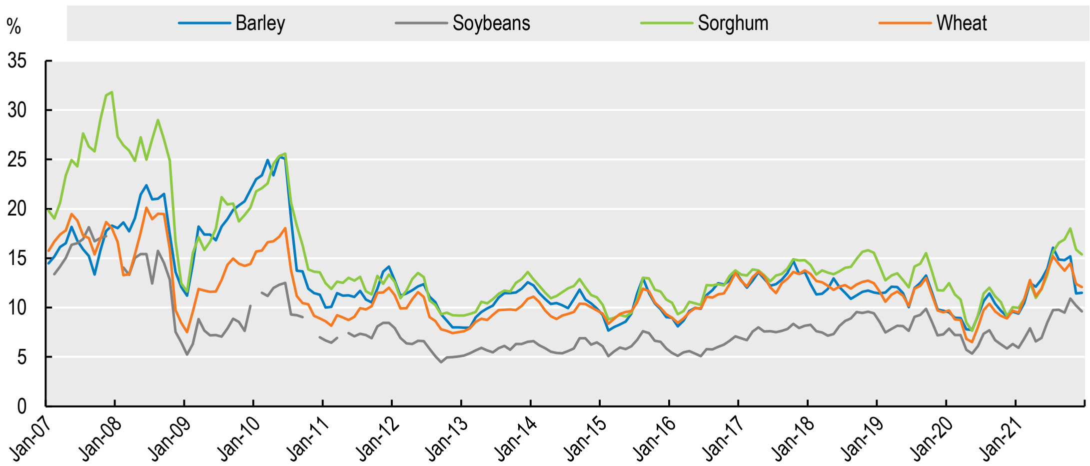
3.4.2. Evolution of the share of freight rates in C&F prices

It is also interesting to examine how the share of freight rates in C&F prices has changed over time. Figure 16 shows the evolution of this share by commodity for the period January 2007 to December 2021.

For all commodities except barley, the share of freight rates in C&F prices peaked between mid-2007 and the end of 2008. The maximum values for soybean, sorghum, and wheat were reached in September 2007 (19.7%), November 2007 (34.8%), and September 2008 (20%), respectively. This share then dropped between late 2008 and early 2009 for all commodities, but went back up again between mid-2009 and mid-2010. The maximum value for barley was reached during this period, at 25.3% in May 2010. Between the end of 2010 and June 2021, the share remained between 5% and 15% for all commodities, reaching a low point in May 2020 at 8%, on average, across all commodities. From May 2020 onwards, this share has been increasing, reaching 10-year record values in the second half of 2021.

Figures 16 also illustrates the differences in the share of freight rate in C&F price between commodities. This share is lower for soybean than for sorghum and wheat, for instance, as these commodities have the same freight rate (i.e. the freight rate for HSS cargoes) but soybean has a higher fob price than sorghum and wheat.

Figure 16. Share of freight rate in C&F price, by commodity (January 2007 – December 2021)



Source: Authors' calculations based on IGC (2022[2]).

4. Determinants of freight rates

The availability of highly disaggregated data on freight rates and fob prices makes it possible to investigate the determinants of freight rates. Preliminary analysis of the data indicated that gravity modelling could not be used because there is not sufficient variation in the database. As mentioned in Section 3.1, the IGC database on freight rates covers the majority of exports in grains and oilseeds; however, these exports are concentrated in just a few countries. Gravity models, by contrast, perform best with large sets of exporting and importing countries that maximize cross-country variation in indicators of interest.

This report therefore uses the methodology suggested by Hummels and Skiba (2004[10]), which shows that freight rates can depend on prices, bilateral distance and quantities shipped (scale economies). A regression with these variables can answer a number of policy-relevant questions, including the following:

- Whether trade costs are iceberg, as assumed in many trade models, or have an additive (per unit) component;

- Whether freight rates are sensitive to distance, and if so, how sensitive; and
- Whether there are scale economies in shipping in this sector.

The first part of this econometric analysis helps identify how to model trade costs in the grains and oilseeds sector: whether they obey the iceberg formulation or have an additive (per unit) component. The iceberg formulation, introduced by Samuelson (1954[11]), assumes that trade costs should be modelled as an ad-valorem tax equivalent (i.e. as a constant percentage of the price per unit traded), implying that pricier goods are costlier to trade. However, recent studies by Irarrazabal, Moxnes, and Opromolla (2015[12]) and Martin (2012[13]) show that transportation costs tend to resemble additive costs (i.e. constant costs per unit traded).

From a policy perspective, the distinction between iceberg costs and additive costs is an important one. Sørensen (2014[14]) shows that modelling trade costs as additive rather than iceberg leads to higher welfare implications from reducing them. This result is also obtained in studies by Irarrazabal, Moxnes and Opromolla (2015[12]) and Daudin, Héricourt and Patureau (2022[15]). Changing the assumed functional form for trade costs can have profound implications for the predictions of trade models. In the Chaney (2008[16]) model, for example, changes in fixed and iceberg costs have different implications in terms of the observed margins of trade, such as more exports to existing markets or new exports to previously unserved markets.

Similarly, scale economies are potentially important, as they suggest that countries that export large quantities (and thereby have higher numbers of maritime shipping calls) may exhibit lower freight rates, thereby increasing their degree of integration into the trade network even further. Conversely, relatively peripheral countries may have their isolation increased by the lack of scale economies.

This section first provides a literature review on the nature and determinants of maritime trade costs. It then describes the data used and explains the methodology. The subsequent sections present the results of the regression analysis and provide robustness checks.

4.1. Literature review

Historically, most models of international trade have used the “iceberg” formulation of trade costs following Samuelson (1954[11]). The idea is that trading goods is like moving an iceberg across the ocean: a portion melts during transit, so the quantity delivered is less than the quantity shipped. An equivalent interpretation in policy terms is that the iceberg formulation captures trade costs as an ad valorem equivalent (AVE). Multiplying the factory gate price in the exporting country by the iceberg factor therefore gives the consumer price in the importing country. As such, trade costs effectively embody all factors that drive a wedge between these two prices (Anderson and van Wincoop, 2004[1]), of which maritime transport costs are one element.

As a first order of magnitude estimate based on previous studies, Anderson and van Wincoop (2004[1]) conclude that total AVE trade costs for a representative developed country are around 170%, broken down into 21% transportation costs, 44% border barriers, and 55% wholesale and retail distribution costs ($2.7 \approx 1.21 * 1.44 * 1.55$). This estimate shows that international transport costs, which in the case of grains and oilseeds are mostly maritime transport costs, are substantial in AVE terms.

Hummels (2007[17]) reviews the evidence on the role of transport cost reductions in driving increases in trade. He shows that in the current trade policy environment, transport costs are typically high in AVE terms relative to tariffs. In addition, there is substantial variation across countries. Using highly disaggregated data for the United States, he shows that maritime freight rates have generally declined in AVE terms over the three decades prior to writing. Innovations during that period included the spread of containerization, as well as other technological changes that improved efficiency and quality in the sector. Interestingly, he finds evidence that freight rates depend on the value of the goods being shipped: higher value goods tend to have higher freight rates. Overall, there is strong evidence that falling freight rates tend to promote trade, although in the latter part of the 20th century, the effect came more from increased speed to due to more accessible air transport, with improvements in maritime transport playing a lesser role.

Many standard trade models use the iceberg assumption, using international transport requirements as the primary motivation. This rationale supports, for example, the inclusion of distance as a determinant of bilateral trade in the gravity formulation. Common structural gravity models generally incorporate trade costs in iceberg format explicitly. Examples include the Armington model of Anderson and van Wincoop

(2003[18]), the Ricardian model of Eaton and Kortum (2002[19]), and the heterogeneous firms model of Chaney (2008[16]). The new generation of general equilibrium models that incorporate gravity equations for bilateral trade also use the iceberg assumption, for example Caliendo and Parro (2014[20]).

Despite the ubiquitous nature of iceberg trade costs in standard models, there are also alternative approaches that emphasize different dimensions of trade costs. The gravity model of Chaney (2008[16]), for example, incorporates fixed costs of market entry in addition to iceberg costs, which produces a richer set of predictions regarding the extensive margin of trade, i.e. entry into new products and new markets. Whereas iceberg costs can be expressed easily in AVE terms, fixed costs of market entry are paid once in order to access a market, but not per unit shipped. The available empirical evidence is consistent with an important role for these kinds of fixed costs as determinants of firm-level trade behaviour, in addition to the effects of iceberg costs (e.g. Eaton, Kortum and Kramarz (2011[21])).

Apart from this different type of cost structure introduced into some models, there is also debate as to how well the iceberg assumption captures the reality of international transportation costs. Bosker and Buringh (2020[22]) show that even the original motivation, namely ice trade based on historical data, is in fact not well proxied by the Samuelson (1954[11]) assumption. Hummels and Skiba (2004[10]) show that transportation costs tend to resemble per unit, rather than AVE, costs. More recently, however, Lashkaripour (2020[23]) shows that accounting for variations in shipment weight can lend greater support to the iceberg assumption.

Changing the assumed functional form for trade costs can have profound implications for the predictions of trade models. In the Chaney (2008[16]) model, for example, changes in fixed and iceberg costs have different implications in terms of the observed margins of trade, for instance more exports to existing markets, or new exports to previously unserved markets. In Hummels and Skiba (2004[10]), the effect relates to quality: with per unit shipping costs, exporters have different incentives to ship higher quality goods. Similarly, Hornok and Koren (2015[24]) show that per unit costs can lead exporters to change their shipment size, which has implications for the welfare gains from trade.

In theoretical models of trade, trade costs are usually regarded as exogenous, i.e. they are determined by factors outside the model. There are exceptions, such as Brancaccio, Kalouptsidi, and Papageorgiou, (2020[25]) where the transport sector is modelled in detail, and trade costs are therefore an equilibrium outcome rather than exogenously given. That paper shows that modelling transport costs as endogenous can produce a rich set of additional insights, including the possibility of network effects in trade costs.

Although typically without a fully developed theoretical framework, the policy literature has also looked at the determinants of maritime transport costs. This approach effectively treats them as endogenous to behaviour by economic agents, including governments (through setting policy). For instance, Clark, Dollar and Micco (2004[26]) show that in addition to distance, volume, and product characteristics, measures of port efficiency are also important predictors of transport costs for maritime shipments. Wilmsmeier and Martínez-Zarzoso (2010[27]) show that certain characteristics of the maritime transport sector also matter for the determination of transport costs: network connectivity and market structure are important, for example, in addition to the product characteristics typically emphasized in the more general literature on trade costs. In relation to the agricultural sector specifically, Korinek and Sourdin (2010[28]) show that distance alone does not explain maritime transport costs; and that those costs have an effect on trade flows independently of distance. Importantly, Bertho, Borchert and Mattoo (2016[29]) show that policy restrictions in maritime shipping markets tend to reduce bilateral trade through their impact on trade costs.

The key takeaway from the recent literature is that while iceberg costs are simple and intuitively appealing, their empirical relevance remains an open question. They may be an acceptable simplification for some products and markets, but not for others. The case of commodities like grains and oilseeds is an interesting one, as, a priori, the expectation is that there is less quality variation than in highly differentiated manufactured goods, which in turn would tend to suggest that the iceberg formulation could be a fair approximation of reality. However, there is also evidence in the policy literature that the pricing of maritime transport may specifically depart from the strict confines of the iceberg approach.

4.2. Data

The regression analysis uses the data on freight rates and fob prices (in USD per tonne) provided by the IGC (IGC, 2022[2]). Monthly bilateral trade flow data (in tonnes) primarily come from the United Nations' Comtrade Database (DESA/UNSD, 2022[30]).[13] Information on the distance between ports (in kilometres) is provided by the International Transport Forum (ITF, 2021[31]).

Even though information on freight rates and fob prices is available from 2007 onwards, the analysis covers the period January 2010 until October 2021 because data on monthly bilateral trade flows are available for that period only. As explained in Section 3, the freight rate database contains more commodities and more routes from 2019 onwards because of the introduction of the freight rate model. In order to obtain a more balanced panel for the analysis, the data have been divided into two consistent datasets:

- Long term (January 2010 – October 2021): This analysis only considers those routes and commodities for which data have been consistently available in the freight database from 2010 onwards.
- Short term (January 2019 – October 2021): This analysis considers all the routes and commodities available in the freight database.

After merging the freight, price, trade and distance databases, the two panel datasets were constructed. The first panel, used in the long term analysis, covers 90 different routes and four commodities (barley, soybeans, sorghum and wheat). The panel for the short term analysis covers 219 routes and also incorporates maize in addition to the four commodities.

4.3. Empirical specification

The empirical analysis examines whether freight rates are influenced by the fob price, the distance between ports and the shipped quantity, following the methodology in Hummels and Skiba (2004[10]). The analysis only considers these three explanatory variables because of different reasons. First and foremost, this model has strong theoretical foundations. Second, information on other variables (e.g. demand and supply of bulk carriers) is not available at the level of detail required for the analysis. Finally, for certain variables (e.g. the oil price), data are available but these variables cannot be included in the regression because there is no variation in those variables for the different import-export-commodity combinations.

To account for time-varying country-specific factors, such as trade policies or infrastructure quality issues among others, exporter-time and importer-time interaction fixed effects are used in addition to the commodity and time fixed effects. Equation (1) illustrates the estimated model, where all variables enter in logarithm. Freight rates and prices are averaged at the monthly level.

$$ln(f_{ijkt}) = \beta_1 \ln(fob_{ikt}) + \beta_2 \ln(dist_{ij}) + \beta_3 \ln(quant_{ijkt}) + \gamma_{it} + \gamma_{jt} + \gamma_k + \gamma_t + \varepsilon_{ijkt} \quad (1)$$

Where:

- f_{ijkt} is the average freight rate for a specific commodity *k,* shipped from country *i* to country *j* in month *t.*
- fob_{ikt} is the average fob price per tonne for commodity *k* in exporting country *i* in month *t.*
- $dist_{ij}$ is the distance between the ports in exporting country *i* and importing country *j*
- $quant_{ijkt}$ is the traded quantity of commodity *k* from country *i* to country *j* in month *t.*
- $\gamma_{it}, \gamma_{jt}, \gamma_k, \gamma_t$ are exporter-time, importer-time, commodity and time fixed effects, respectively.

[13] When available, missing data on bilateral trade flows in the Comtrade database were complemented by data from the IGC (IGC, 2022[2]).

To test whether freight rates are affected by prices in the previous month, the model is also estimated by including a one-month lag of the price variable instead of the contemporaneous variable.

4.4. Results

The regression results are presented in Table 4. As specified above, two different samples are used depending on the period of analysis. The results for the long-term analysis are reported in columns (1) and (2), and the results for the short-term analysis are reported in columns (3) and (4). For each period of analysis, two regressions are run: one which incorporates the current fob price (columns (1) and (3)), and one which uses the one-month lagged fob price instead (columns (2) and (4)).

Starting with the long-term analysis, the results suggest that the fob price has no statistically significant impact on the freight rate, and this is the case for both the current and the one-month lagged fob price. Examining the coefficient on the fob price also allows answering the iceberg question, since Hummels and Skiba (2004[10]) show that testing the iceberg assumption amounts to testing the hypothesis that the elasticity of freight rates with respect to unit prices, i.e. β_1, is equal to one. The table reports the results of an F-test with the null hypothesis that $\beta_1=1$. The data reject the null hypothesis at the 1% level of significance, which means that the costs are not iceberg but are additive, as was the case in the Hummels and Skiba (2004[10]) paper.

Table 4. Regression results

	Long term (01.2010-10.2021)			Short term (01.2019-10.2021)	
VARIABLES	(1)	(2)		(3)	(4)
ln(fob)	-0.0223			-0.0755***	
	(0.0329)			(0.0131)	
L.ln(fob)		-0.0165			-0.0774***
		(0.0330)			(0.00752)
ln(distance)	0.226**	0.218*		0.259***	0.261***
	(0.0511)	(0.0510)		(0.0396)	(0.0389)
ln(traded quantity)	0.000475	0.000160		-0.000170	-0.000220
	(0.00231)	(0.00237)		(0.00166)	(0.00168)
Constant	1.452	1.493		1.452***	1.446**
	(0.633)	(0.648)		(0.290)	(0.318)
Observations	7,178	6,996		5,540	5,358
R-squared	0.944	0.944		0.951	0.953
F-stat ($\beta_1 = 1$)	965.9	946.0		6714	20504
p-stat	0.00	0.00		0.00	0.00

Note: *** p<0.01, ** p<0.05, * p<0.1. Standard errors are clustered[14] at the exporter-importer-commodity triplet to correct for potential correlation of errors across these triplets.

[14] Clustering means that the standard errors of estimated coefficients are allowed to have different distributions based on the importing country, exporting country and commodity triplet. This mitigates possible skewness of results that arises from not including unobserved variables that differ systematically by importing country, exporting country and commodity triplets.

The long-term analysis shows a robust effect of distance on freight rates as its coefficient is positive and statistically significant at the 5% and 10% level in the regressions with current and one-month lagged fob price, respectively. This result suggests that freight costs increase as grains and oilseeds are shipped over longer distances. More specifically, a 10% increase in the bilateral distance between two ports leads to a 2.2% increase in the freight rates.

The last dimension to investigate is whether scale economies are an important determinant of freight rates in the grains and oilseeds sector. Hummels and Skiba (2004[10]) show that scale economies exist if the coefficient on the traded quantity is negative and statistically significant. However, the results show that freight rates are not affected by the volume of shipped grains and oilseeds. One potential explanation might be that, even though using larger carriers may provide some economies in terms of per tonne vessel hire costs (i.e. time charter rates divided by the amount carried) or fuel consumption per tonne of cargo, a larger vessel also means (in most cases) higher port and canal charges and longer load and discharge times.

Columns (3) and (4) report the results for the short-term analysis. Even though this sample covers a shorter period, it is interesting to examine how the results change when more routes and commodities are covered. Similar to the long-term analysis, distance has a positive and statistically significant effect on freight rates: a 10% increase in the bilateral distance between two ports leads to a 2.6% increase in the freight rate. Like the long-term analysis, there are no economies of scale. The results of the F-test in the short-term analysis confirm that the iceberg assumption can be rejected at 1% significance level, underlining that trade costs are additive and not ad-valorem.

However, contrary to the long-term regression, the fob price has a negative and significant impact on freight rates in the short-term analysis, and this result holds for both the current and lagged fob price. More specifically, a 10% increase in the current or one-month lagged fob price leads to a 0.8% decrease in freight rates. This result suggests that exporters facing increasing commodity prices tend to try to negotiate lower freight rates in efforts to stay competitive. In 2021, this was for example observed in Argentina, where an increase in maize prices led to the country lowering its freight rates for shipments to Southeast Asia, and Viet Nam in particular, to remain competitive.

The sign for the fob price is negative in both the long-term and short-term analysis, but the result that the fob price is only statistically significant over the short term can be due to several factors. First, there are more routes and more commodities covered in the short-term analysis than in the long-term analysis. Second, the short-term analysis focuses on an exceptional period that is characterised by strong increases in freight rates, high volatility in freight rates, logistical issues and disruptions in supply chains.

To test whether the results are sensitive to the model specifications, several robustness checks were performed (Annex B). The results of the robustness checks confirm the results in Table 4. More specifically, i) the distance over which grains and oilseeds are shipped is a crucial determinant of freight rates, ii) the current and one-month lagged fob price have no significant impact on freight rates in the long-term analysis, but have a negative impact on freight rates in the short-term analysis, iii) the quantity shipped has no significant impact on freight rates, and iv) additive costs are important in the maritime transport of grains and oilseeds.

The selected data and methodology have several limitations. First, due to data availability issues, the impacts of several determinants cannot be examined, such as, for example, the supply and demand of bulk carriers or port congestion. Second, in light of the rising energy prices, it would be interesting to examine the relative importance of the oil price in freight costs. However, the oil price cannot be included in the selected model because there is no variation in this variable for the different import-export-commodity combinations. Finally, the results of the long-term and short-term analysis are not directly comparable because the short-term analysis covers significantly more routes than the long-term analysis and also includes maize in addition to HSS and barley.

5. Network analysis of freight rates

The relative importance of importers and exporters can be examined using network analysis. Although well-developed in applied mathematics and physics, network analysis is still relatively uncommon in the economics literature, including in international trade. Most contributions tend to be descriptive, focusing on particular properties of the maritime transport network, for example Hu and Zhu (2009[32]). Shepherd (2017[33]) shows that measures of network centrality matter from the point of view of trade integration and Jouanjean, Gourdon and Korinek (2017[34]) use network analysis to explore the relationship between global value chain (GVC) participation and economic transformation at the sectoral level, however there are no agricultural sector-specific insights. While policy initiatives like the UNCTAD Liner Shipping Bilateral Connectivity Index seek to capture key variables determining maritime connections at a bilateral level, they do not take account of the analytical literature on networks (UNCTAD, 2021[35]).

The IGC freight rate database enables examining how closely ports are connected based on the cost to move grains and oilseeds between them. This section first represents the connection between ports with network visualisation and then uses the concept of centrality to show the relevance of a port in the network. The analysis focuses on the years 2020 and 2021 because the database is more complete for these years. As illustrated in Table 1, the database covers almost 340 routes in 2020 and 2021 compared to around 100 routes in the years before the introduction of the freight rate model. It should be noted that the IGC database only covers key routes based on volume traded and that the analysis below hence does not include all possible routes.

Even though the freight rate database contains information at the port level, the figures and tables in this section show the country name for easier identification. For the countries with more than one port in the IGC freight rate database, the country name is represented by the ISO3 code and the name (or first letter(s)) of the port is specified. Annex E lists all countries and ports and specifies which cargo they import or export.

5.1. Network visualisation

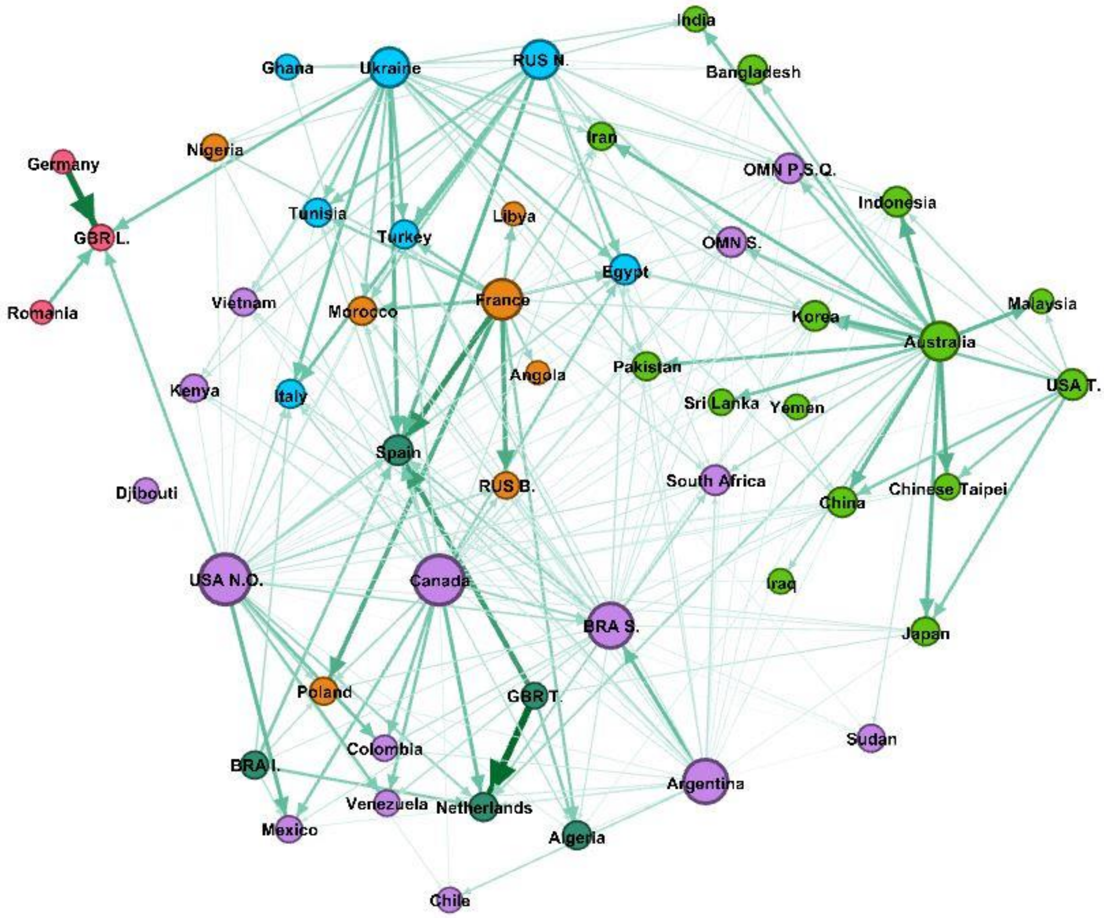
A network of importers and exporters can be illustrated with nodes (ports), which are connected to each other by edges if goods are shipped between them. To illustrate the strength of the connections, the edges can be weighted. Since this report aims to examine the role of freight rates between countries, the weighting is based on the inverse of the freight rate: a higher freight rate gives a lower weight. This weighting scheme hence shows the strength of connection based on the costs of shipping the commodities.

Figure 17 and Figure 18 represent the network of HSS shipments, and of maize and barley shipments, respectively, in December 2021. This month was selected because it is the most recent month of freight rate data used in the analysis. Section 5.2. explores how networks change over time.

These figures contain several pieces of information. First, each node represents a port that receives or ships out HSS (Figure 17), maize or barley (Figure 18). The larger the diameter of the node, the more connections that node (port) has with other nodes (ports). Second, the figures are directed: the edges have arrows indicating the direction of the shipments from the origin port to the destination port. Almost all arrows are one-directional because in the IGC freight database the ports that import a certain commodity, usually do not export this commodity, and vice versa.[15] The darkness of the edges represents the strength of the connection: the darker the colour of the edge, the stronger the connection. Since the edges are weighted by the inverse of the freight rate, this implies that as the maritime transportation cost between two ports is lower, their connection is stronger, and the edge's colour is darker. Finally, the colour of the nodes identifies clusters of ports that interact relatively more among each other than with other ports.

[15] The only exception is the port of Santos in Brazil, which enters the IGC freight database as both an origin port and destination port of HSS. More specifically, the port of Santos exports mainly soybeans and imports predominantly wheat, but because both of these commodities are part of the cargo HSS and freight rates are not available for wheat and soybeans separately, it is unfortunately not possible to make this distinction.

Figure 17. Network representation of HSS shipments in December 2021



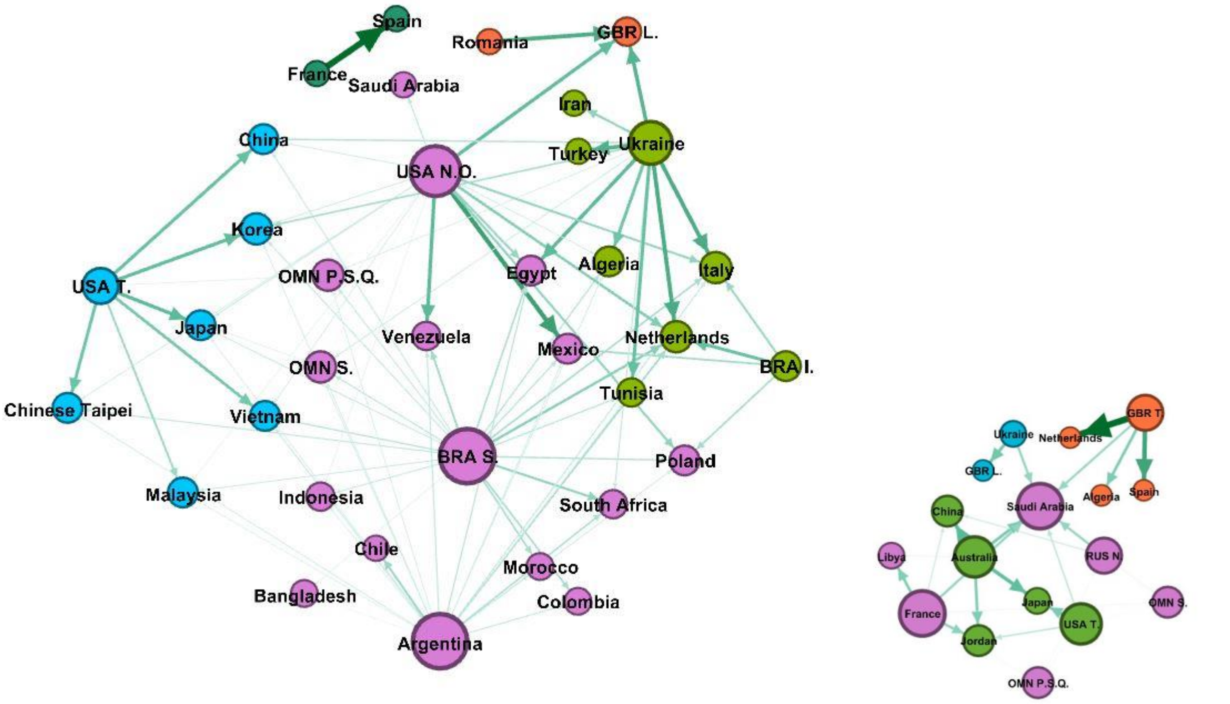
Note: The nodes represent ports. For easier identification the name of the country is displayed instead of the port name. For countries with two ports in the IGC database, the country name is represented by the ISO3 code and the first letter(s) of the name of the port is specified. The diameter of the node increases as the port has more connections. The one-directional edges illustrate the direction of shipment. Edges are weighted by the inverse of the freight rate and darker edges between two nodes represent relatively lower freight rates and hence stronger connections.
Source: Authors' calculations based on IGC (2022[2]).

Figure 17 shows that the HSS network is characterised by a high density of nodes and connections. As identified by the dimension of the node, the port of New Orleans in the United States and the port of Baie-Comeau in Canada have the highest number of connections and thus play a central role in the network. In December 2021, based on the IGC route coverage, these two ports shipped HSS goods to respectively 35 and 34 ports.[16] On the importing side, ports that receive HSS from a relatively larger number of ports are situated in Egypt, China, South Africa, Korea, Indonesia, Spain and Oman. These countries diversify their HSS import sources instead of relying on only one or a few ports.

The left panel of Figure 18 illustrates that in the maize network, the ports that have the most connections are Argentina and Brazil (port of Santos). The ports of Korea, Italy, Netherlands and Oman are importing maize from five different ports, distinguishing themselves from the other countries with a higher level of diversification. The right panel of Figure 18 shows that for barley France's port is connected to the most ports on the export side, while the port of Saudi Arabia has the most connections on the import side.

[16] The IGC database does not cover all possible routes, but only selected key routes based on volumes traded. It is therefore most likely that these ports shipped grain cargoes to much more ports than indicated, but those shipments were likely smaller and hence not included in the IGC coverage.

Figure 18. Network representation of maize (left) and barley (right) shipments in December 2021



Note: The nodes represent ports. For easier identification the name of the country is displayed instead of the port name. For countries with two ports in the IGC database, the country name is represented by the ISO3 code and the first letter(s) of the name of the port is specified. The diameter of the node increases as the port has more connections. The one-directional edges illustrate the direction of shipment. Edges are weighted by the inverse of the freight rate and darker edges between two nodes represent relatively lower freight rates and hence stronger connections.
Source: Authors' calculations based on IGC (2022[2]).

5.2. Weighted hub and authority centrality

There are different ways to summarise the importance of a node in a network or, in this report, the importance of a port in the international network of grains and oilseeds shipments. The most relevant measure for the directed and weighted network figures in this report is hub and authority centrality.[17] A hub is a node that points to other nodes, while an authority is a node being pointed-to by other nodes. In this report, a higher hub centrality score corresponds to a port being more important as an exporter, while a higher authority centrality score is associated with a port that is more important as an importer. As mentioned above, with the exception of the port of Santos in Brazil for HSS, all ports in the IGC database that export a certain cargo are not importing this cargo, and vice versa. This means that only the port of Santos is a hub and authority of HSS, while all the other nodes (ports) are either a hub or an authority.

The centrality measure hence considers the number of connections that each port has with another port and is represented in Figures 17 and 18 by the diameter of the nodes. To incorporate the strength of the connections, which is illustrated in these figures by the thickness of the connecting edges, the centrality measures are weighted by the inverse of the freight rate. The weighted centrality hence shows the importance of a node in a network by considering both the number of connections and the strength of the connections.

[17] The metrics of hub and authority centrality were first proposed by Kleinberg (1999[38]), who designed the HITS (Hypertext Induced Topic Search) algorithm to rate webpages. The measure of centrality is obtained by first establishing the number of inward and outward connections of each port and then using the adjacency matrix coming from the network and its transpose. It is computed as follows: (1) $A^T y = \lambda y$; and (2) $A^T A x = \lambda x$, where A is an NxN matrix and A^T is its transpose. λ is the largest eigenvalue of the matrix A, and x and y are, respectively, the vectors with the value of the authority and hub.

The weighted hub and authority centrality can be traced over time to examine whether certain ports have become more or less important in the network. A port can have a more central role in the network over time because it exports to (imports from) more ports, the freight rates that it faces have decreased or a combination of the two.

A first way to examine weighted centrality is to compare the values for January 2020 and December 2021, the first and last month in the database used for this section. January 2020 gives an idea of the situation before the COVID-19 pandemic, while December 2021 shows the most recent situation.

Figure 19 shows the weighted hub centrality, by cargo, for January 2020 (small dot) and December 2021 (large dot). Comparing these two points in time shows that several ports became more important as exporters in the network, while other ports lost some centrality. For HSS, the ports in Australia, Itaqui in Brazil, and New Orleans and Tacoma in the United States became more important, while the ports in Argentina and Santos in Brazil experienced a decrease in weighted hub centrality. For maize, the weighted centrality between January 2020 and December 2021 increased the most for the ports of Itaqui in Brazil and New Orleans and Tacoma in the United States, and decreased the most for the ports in Argentina and Santos in Brazil. The port of Tilbury in the United Kingdom became more important for barley exports, while the ports in France and Australia lost some centrality, but remain the most important ports for exporting barley in December 2021.

Figure 20 illustrates which ports have become more or less important as importers of HSS, maize and barley between January 2020 and December 2021. For all three cargos, there have been changes in the structure of the network. In the case of HSS, the ports in Iran, China and Korea experienced the largest increase in weighted centrality, while Algeria, Spain, Tunisia and Turkey had the largest decreases. China became also relatively more central as an importer of maize, while the ports in Colombia and Morocco experienced the largest decrease in weighted centrality. For barley, the ports in the Netherlands and Spain gained importance in the network as importers, while China, Jordan and Libya became relatively less central in the network.

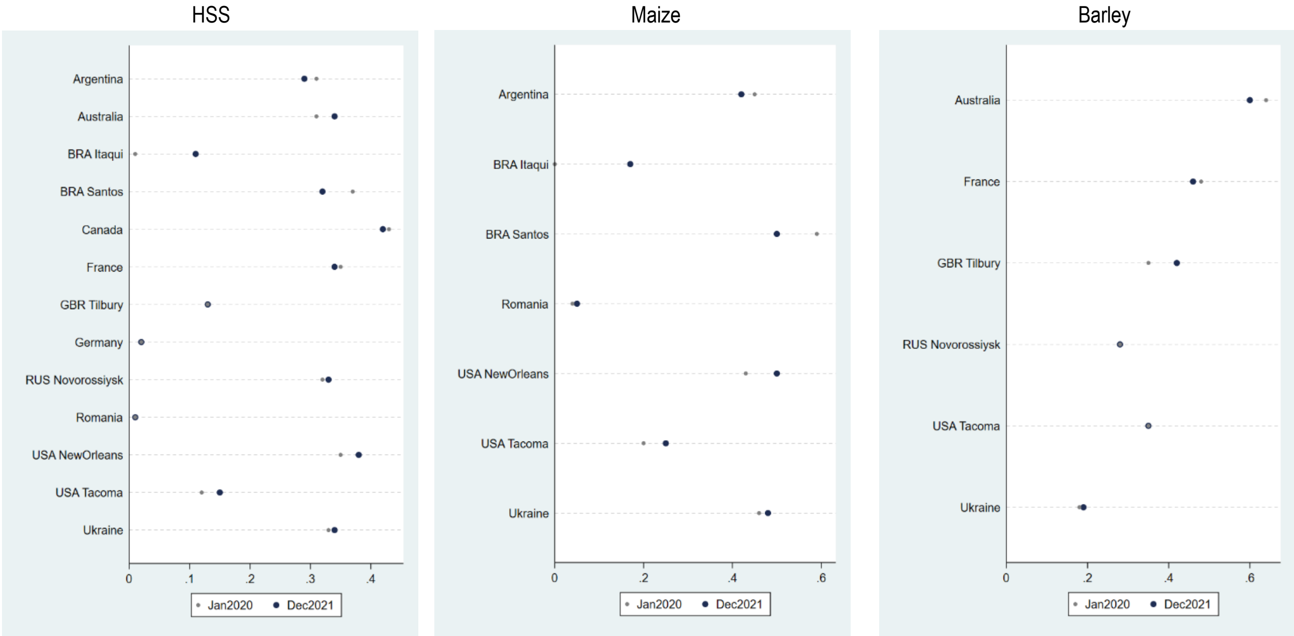
Figures 19 and 20 clearly illustrate how the network structure of international shipments of grains and oilseeds constantly evolves, with certain ports gaining in importance and others becoming relatively less central in the network. The relative changes in importance, however, do not seem to vary significantly. That is, there appear to be certain ports that display higher weighted hub or authority centralities than other ports and even though there are some upward and downward changes in these values between January 2020 and December 2021, these ports with the highest centralities appear to remain the same between the two points in time.

To examine whether the most important importers and exporters in the network of global shipments of grains and oilseeds vary over time, Table 5 lists the top five countries with the highest hub and authority centrality, by cargo, during the last two years. More specifically, six-month averages of weighted centrality are calculated for the last two years and the five countries with the highest centrality for each six-month period are listed. Countries that appear in the top five in each six-month period for a given cargo and centrality (hub or authority) are indicated in black font; the other countries are indicated in blue font. Annex C provides these averages for all ports in the database.

On the export side are the ports of Baie-Comeau in Canada and of Santos in Brazil consistently the most central ports in the network of HSS and maize, respectively, with the highest weighted hub centrality during the last two years. Moreover, for those two cargoes, the list of countries in the top four have remained the same. The most important port for barley exports was Kwinana in Australia in 2020 and Tilbury in the United Kingdom in 2021. For barley, the same five countries had the highest weighted hub centrality, but their relative importance changed in the different six-month periods.

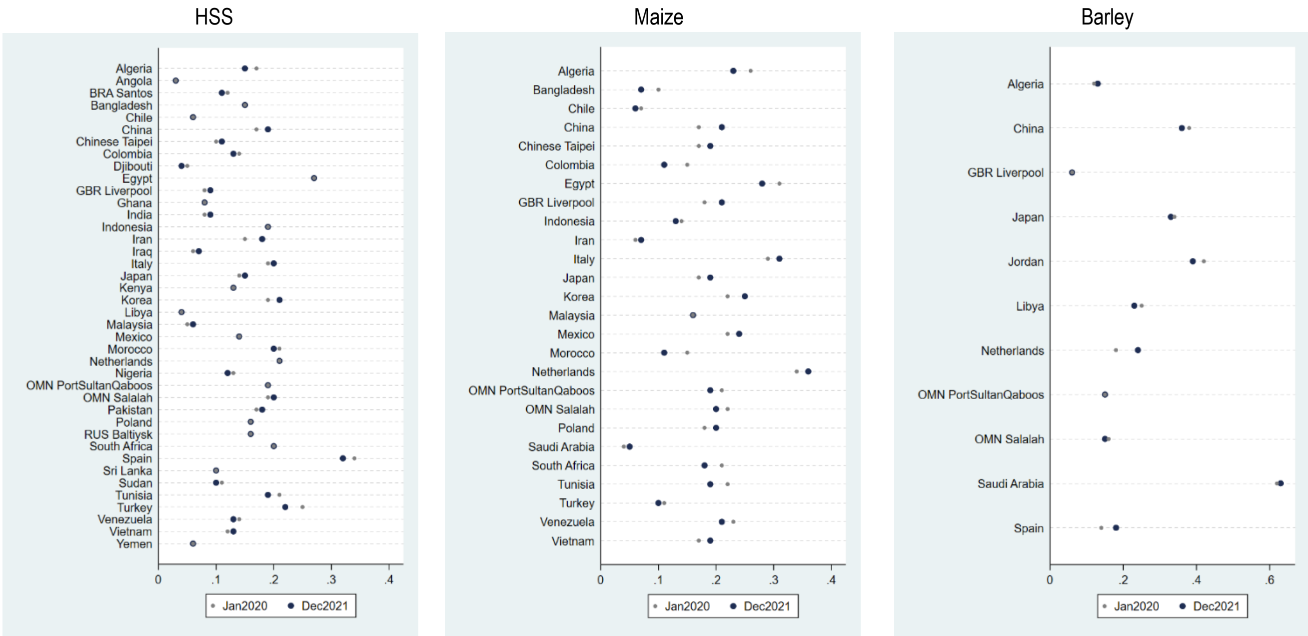
Exports of grains and oilseeds is concentrated in a handful countries, whereas imports are more dispersed. This is also illustrated in Annex E where the list of importing ports is much longer than the list of exporting ports. Nevertheless, the weighted authority centrality shows that the most important ports in terms of imports have not changed very much in the last two years. For HSS, the ports of Cartagena in Spain and Alexandria in Egypt are the most important ones, while the ports of Rotterdam in the Netherlands and Genoa in Italy are the most central ports for maize. In the case of barley imports, the port of Jeddah in Saudi Arabia consistently displays a much higher weighted authority centrality. As is the case with the hub centrality, the list of the top three or four countries remained the same for the last two years.

Figure 19. Weighted hub centrality for January 2020 and December 2021, by cargo



Note: For easier identification the name of the country is displayed instead of the port name. For countries with two ports in the IGC database, the country name is represented by the ISO3 code and the name of the port is specified.
Source: Authors' calculations based on IGC (2022[2]).

Figure 20. Weighted authority centrality for January 2020 and December 2021, by cargo



Note: For easier identification the name of the country is displayed instead of the port name. For countries with two ports in the IGC database, the country name is represented by the ISO3 code and the name of the port is specified.
Source: Authors' calculations based on IGC (2022[2]).

Table 5. Top five origin and destination countries with highest average hub and authority weighted centrality – six month averages 2020-2021

	Cargo		Jan-Jun 2020		Jul-Dec 2020		Jan-Jun 2021		Jul-Dec 2021
Hub	HSS	Canada	0.44	Canada	0.42	Canada	0.43	Canada	0.43
		BRA S.	0.38	BRA S.	0.38	USA N.O.	0.38	USA N.O.	0.39
		USA N.O.	0.35	USA N.O.	0.36	BRA S.	0.35	France	0.35
		France	0.34	France	0.32	France	0.35	BRA S.	0.33
		Ukraine	0.32	Argentina	0.32	Ukraine	0.33	Ukraine	0.33
	Maize	BRA S.	0.61	BRA S.	0.61	BRA S.	0.55	BRA S.	0.51
		Ukraine	0.47	Argentina	0.46	Ukraine	0.47	USA N.O.	0.50
		Argentina	0.44	Ukraine	0.43	USA N.O.	0.46	Ukraine	0.48
		USA N.O.	0.42	USA N.O.	0.41	Argentina	0.44	Argentina	0.43
		USA T.	0.18	USA T.	0.18	BRA I.	0.19	USA T.	0.20
	Barley	Australia	0.66	Australia	0.63	GBR T.	0.63	GBR T.	0.63
		France	0.47	France	0.48	Australia	0.44	Australia	0.46
		USA T.	0.36	USA T.	0.37	France	0.41	France	0.39
		GBR T.	0.32	GBR T.	0.35	USA T.	0.27	USA T.	0.28
		RUS N.	0.27	RUS N.	0.29	RUS N.	0.26	RUS N.	0.25
Authority	HSS	Spain	0.33	Egypt	0.30	Spain	0.31	Spain	0.33
		Egypt	0.30	Spain	0.29	Egypt	0.28	Egypt	0.28
		Turkey	0.26	Turkey	0.25	Turkey	0.25	Turkey	0.23
		Morocco	0.22	South Africa	0.22	Morocco	0.22	Morocco	0.22
		South Africa	0.22	Morocco	0.22	Italy	0.22	Italy	0.21
	Maize	Netherlands	0.35	Italy	0.32	Netherlands	0.34	Netherlands	0.36
		Egypt	0.33	Netherlands	0.32	Italy	0.34	Italy	0.33
		Italy	0.30	Egypt	0.30	Egypt	0.30	Egypt	0.29
		Algeria	0.27	Algeria	0.25	Mexico	0.26	Mexico	0.25
		South Africa	0.23	Mexico	0.25	Algeria	0.25	Algeria	0.24
	Barley	Saudi Arabia	0.60	Saudi Arabia	0.61	Saudi Arabia	0.57	Saudi Arabia	0.56
		Jordan	0.42	Jordan	0.41	Netherlands	0.39	Netherlands	0.41
		China	0.38	China	0.37	Spain	0.30	Spain	0.30
		Japan	0.35	Japan	0.34	Jordan	0.29	Jordan	0.29
		Libya	0.27	Libya	0.26	China	0.27	China	0.28

Note: For easier identification the name of the country is displayed instead of the port name. For countries with two ports in the IGC database, the country name is represented by the ISO3 code and the first letter(s) of the name of the port is specified. Countries which appear in the top 5 for each six-month period are indicated with a black font, the other countries are indicated with blue font.
Source: Authors' calculations based on IGC (2022[2]).

6. Conclusion

This report examines maritime transportation costs in the grains and oilseeds sector using the database on ocean freight rates developed by the IGC. Five key findings emerge from the analysis. First, although freight rates have increased sharply in the last two years, they were still lower in both absolute terms and in volatility terms at their peak value of October 2021 than during the food price crisis of 2007-08. Second, freight rates can play an important role in consumer prices. The analysis shows that, on average, maritime transportation costs account for 11% of the cost and freight price during the period 2007-2021, but this share ranges from 2% to 43%. Moreover, freight rates are generally more volatile than fob prices. Third, the regression analysis demonstrates that distance is the most important determinant of freight rates; a 10% increase in the distance between two ports is estimated to lead to a 2.5% increase in freight rates. The quantity shipped, however, has no significant impact on freight rates. In the long-term analysis (2010-2021), the current and one-month lagged fob price have no effect on freight rates. This result changes when focusing on the recent time period (January 2019-October 2021), which was characterised by rising freight rates, high volatility and supply chain disruptions. During this recent period, a 10% increase in fob prices leads to a 0.8% decrease in freight rates. Fourth, the analysis shows that transportation costs in the grains and oilseeds sector do not obey the iceberg formulation. This has both modelling and welfare implications. More specifically, it implies that these costs should be modelled as additive (per unit) rather than as iceberg (constant percentage of the price per unit traded). Moreover, previous research shows that the welfare gains from reducing these costs are higher than if they were iceberg costs. Fifth, based on the IGC route coverage, the most central ports in the network of grains and oilseeds shipments have remained the same in 2020 and 2021. That is, for each cargo (HSS, barley and maize) the list of the top three or four most important ports for exports and for imports was composed of the same ports.

The considerable share of freight rates in the cost and freight price of grains and oilseeds and the relatively higher volatility of freight rates than fob prices reinforces the importance to have reliable, transparent and timely information on freight rates. The IGC already provides this information to the Agricultural Market Information System (AMIS) Initiative, and trends in ocean freight rates are published each month in the AMIS monitor (AMIS, 2022[36]). In addition, it is important to also have transparent information on the components and determinants of freight rates, such as the supply and demand of bulk carriers, vessel hire costs, fuel costs, etc. Some of this information is however proprietary and hence more difficult to obtain.

Higher freight rates can lead to higher commodity and food prices, thereby threatening the food security of the millions of people who depend on staple crops for their diet. Furthermore, a select number of ports play a crucial role in importing and exporting grains and oilseeds, which implies that any disruption or logistical problem can quickly escalate and have serious impacts on shipments and thus availability of commodities. This was for example the case during the first months of the COVID-19 pandemic, when restrictions such as lockdowns, social distancing measures and reduced mobility limited the transport of goods. In response, many countries classified the food and agriculture sector as “essential” to facilitate the free movement of goods and people. This illustrates the importance of introducing measures that guarantee that shipments of grains and oilseeds can reach their destinations. Conversely, policy measures such as export restrictions, which are shown to contribute to rising and volatile food prices and can jeopardise food security, should be avoided.

Reducing trade costs leads to welfare gains. In the case of grains and oilseeds, maritime transportation costs are a large component of the overall trade costs. Since the results in this paper show that maritime transportation costs in grains and oilseeds sector are additive, the potential welfare gains can be higher than if the costs were iceberg. Future research could quantify the welfare gains that are achieved through a reduction in these additive maritime transportation costs.

The report highlights the important role of Russia and Ukraine as key suppliers of grains and oilseeds to international markets. The analysis in this report covers the period until the end of 2021. Future research based on the methodology and data in this report could examine how the large scale aggression of Russia against Ukraine has affected freight rates and how trade patterns have adjusted to the crisis.

References

AMIS (2022), *Agricultural Market Information System - Market Monitor*, http://www.amis-outlook.org/amis-monitoring/monthly-report/en/#.Yid0ZXrMIuU (accessed on March 2022). [36]

Anderson, J. and E. van Wincoop (2004), "Trade Costs", *Journal of Economic Literature*, Vol. 42/3, pp. 691-751, https://doi.org/10.1257/0022051042177649. [1]

Anderson, J. and E. van Wincoop (2003), "Gravity with Gravitas: A Solution to the Border Puzzle", *American Economic Review*, Vol. 93/1, pp. 170-192, https://doi.org/10.1257/000282803321455214. [18]

Arriola, C., P. Kowalski and F. van Tongeren (2021), "The impact of COVID-19 on directions and structure of international trade", *OECD Trade Policy Papers*, No. 252, OECD Publishing, Paris, https://dx.doi.org/10.1787/0b8eaafe-en. [3]

Baltic Exchange (2022), *Baltic Exchange Market Information*, https://www.balticexchange.com/en/index.html (accessed on February 2022). [5]

Bertho, F., I. Borchert and A. Mattoo (2016), "The trade reducing effects of restrictions on liner shipping", *Journal of Comparative Economics*, Vol. 44/2, pp. 231-242, https://doi.org/10.1016/j.jce.2016.03.001. [29]

Bosker, M. and E. Buringh (2020), "Ice(berg) Transport Costs", *The Economic Journal*, Vol. 130/629, pp. 1262-1287, https://doi.org/10.1093/ej/ueaa023. [22]

Brancaccio, G., M. Kalouptsidi and T. Papageorgiou (2020), "Geography, Transportation, and Endogenous Trade Costs", *Econometrica*, Vol. 88/2, pp. 657-691, https://doi.org/10.3982/ecta15455. [25]

Caliendo, L. and F. Parro (2014), "Estimates of the Trade and Welfare Effects of NAFTA", *The Review of Economic Studies*, Vol. 82/1, pp. 1-44, https://doi.org/10.1093/restud/rdu035. [20]

Chaney, T. (2008), "Distorted Gravity: The Intensive and Extensive Margins of International Trade", *American Economic Review*, Vol. 98/4, pp. 1707-1721, https://doi.org/10.1257/aer.98.4.1707. [16]

Clark, X., D. Dollar and A. Micco (2004), "Port efficiency, maritime transport costs, and bilateral trade", *Journal of Development Economics*, Vol. 75/2, pp. 417-450, https://doi.org/10.1016/j.jdeveco.2004.06.005. [26]

Daudin, G., J. Héricourt and L. Patureau (2022), *International Transport costs: New Findings from modeling additive cost*. [15]

DESA/UNSD (2022), *United Nations' Comtrade database*, https://comtrade.un.org/data/ (accessed on February 2022). [30]

Eaton, J. and S. Kortum (2002), "Technology, Geography, and Trade", *Econometrica*, Vol. 70/5, pp. 1741-1779, https://doi.org/10.1111/1468-0262.00352. [19]

Eaton, J., S. Kortum and F. Kramarz (2011), "An Anatomy of International Trade: Evidence From French Firms", *Econometrica*, Vol. 79/5, pp. 1453-1498, https://doi.org/10.3982/ecta8318. [21]

FAO (2017), *What did we Learn from the Bout of High and Volatile Food Commodity Prices (2007-2013)?*, FAO, http://www.fao.org/3/a-i7466e.pdf. [9]

Hornok, C. and M. Koren (2015), "Administrative barriers to trade", *Journal of International Economics*, Vol. 96, pp. S110-S122, https://doi.org/10.1016/j.jinteco.2015.01.002. [24]

Howe Robinson Partners (2020), *Bulk & Container Freight Market Review and Outlook*, https://www.howerobinson.com/wp-content/uploads/2020/10/Bulk-Container-market-review.mp4 (accessed on February 2021). [6]

Hummels, D. (2007), "Transportation Costs and International Trade in the Second Era of Globalization", *Journal of Economic Perspectives*, Vol. 21/3, pp. 131-154, https://doi.org/10.1257/jep.21.3.131. [17]

Hummels, D. and A. Skiba (2004), "Shipping the Good Apples Out? An Empirical Confirmation of the Alchian-Allen Conjecture", *Journal of Political Economy*, Vol. 112/6, pp. 1384-1402, https://doi.org/10.1086/422562. [10]

Hu, Y. and D. Zhu (2009), "Empirical analysis of the worldwide maritime transportation network", *Physica A: Statistical Mechanics and its Applications*, Vol. 388/10, pp. 2061-2071, https://doi.org/10.1016/j.physa.2008.12.016. [32]

IGC (2022), *International Grains Council Market Data*, https://www.igc.int (accessed on February 2022). [2]

INSEE (2021), *Fob (free on board) price*, https://www.insee.fr/en/metadonnees/definition/c1347. [8]

International Grains Council (2019), *Dry Bulk Freight: Voyage Rates Modelling Overview*. [7]

Irarrazabal, A., A. Moxnes and L. Opromolla (2015), "The Tip of the Iceberg: A Quantitative Framework for Estimating Trade Costs", *Review of Economics and Statistics*, Vol. 97/4, pp. 777-792, https://doi.org/10.1162/rest_a_00517. [12]

ITF (2021), *ITF Transport Outlook 2021*, OECD Publishing, Paris, https://dx.doi.org/10.1787/16826a30-en. [31]

Jouanjean, M., J. Gourdon and J. Korinek (2017), "GVC Participation and Economic Transformation: Lessons from three sectors", *OECD Trade Policy Papers*, No. 207, OECD Publishing, Paris, https://dx.doi.org/10.1787/617d7a19-en. [34]

Kleinberg, J. (1999), "Authoritative sources in a hyperlinked environment", *Journal of the ACM*, Vol. 46/5, pp. 604-632, https://doi.org/10.1145/324133.324140. [38]

Korinek, J. and P. Sourdin (2010), "Clarifying Trade Costs: Maritime Transport and Its Effect on Agricultural Trade", *Applied Economic Perspectives and Policy*, Vol. 32/3, pp. 417-435, https://doi.org/10.1093/aepp/ppq007. [28]

Lashkaripour, A. (2020), "Weight-based quality specialization", *Journal of International Economics*, Vol. 127, p. 103380, https://doi.org/10.1016/j.jinteco.2020.103380. [23]

Martin, J. (2012), "Markups, quality, and transport costs", *European Economic Review*, Vol. 56/4, pp. 777-791, https://doi.org/10.1016/j.euroecorev.2012.02.004. [13]

Samuelson, P. (1954), “The Transfer Problem and Transport Costs, II: Analysis of Effects of Trade Impediments”, *The Economic Journal*, Vol. 64/254, p. 264, https://doi.org/10.2307/2226834. [11]

Shepherd, B. (2017), “Infrastructure, trade facilitation, and network connectivity in Sub-Saharan Africa”, *Journal of African Trade*, Vol. 3/1-2, p. 1, https://doi.org/10.1016/j.joat.2017.05.001. [33]

Sørensen, A. (2014), “Additive versus multiplicative trade costs and the gains from trade liberalizations”, *Canadian Journal of Economics/Revue canadienne d’économique*, Vol. 47/3, pp. 1032-1046, https://doi.org/10.1111/caje.12101. [14]

UNCTAD (2021), *Liner Shipping Bilateral Connectivity Index*, https://unctadstat.unctad.org/wds/TableViewer/tableView.aspx?ReportId=96618 (accessed on March 2021). [35]

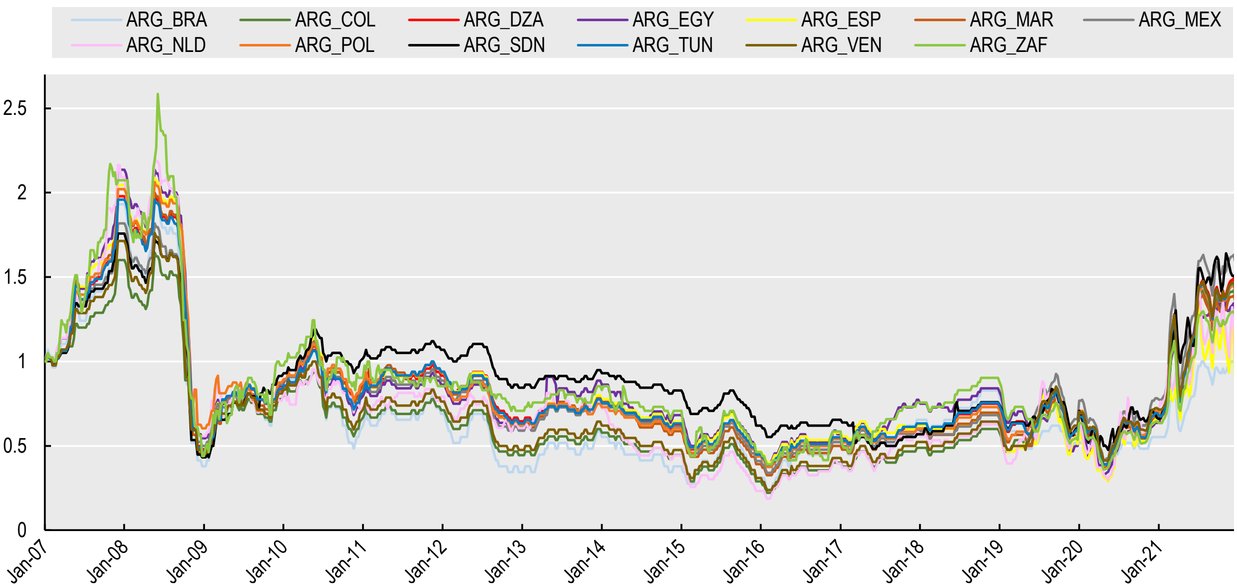
UNCTAD (2020), *Review of maritime transport 2020*, https://unctad.org/system/files/official-document/rmt2020_en.pdf. [4]

USDA (2019), *Profiles of top US agricultural ports*, https://www.ams.usda.gov/sites/default/files/PortProfilesUpdate2017FULLPDFVERSIONWITHTOC.pdf. [37]

Wilmsmeier, G. and I. Martínez-Zarzoso (2010), “Determinants of maritime transport costs – a panel data analysis for Latin American trade”, *Transportation Planning and Technology*, Vol. 33/1, pp. 105-121, https://doi.org/10.1080/03081060903429447. [27]

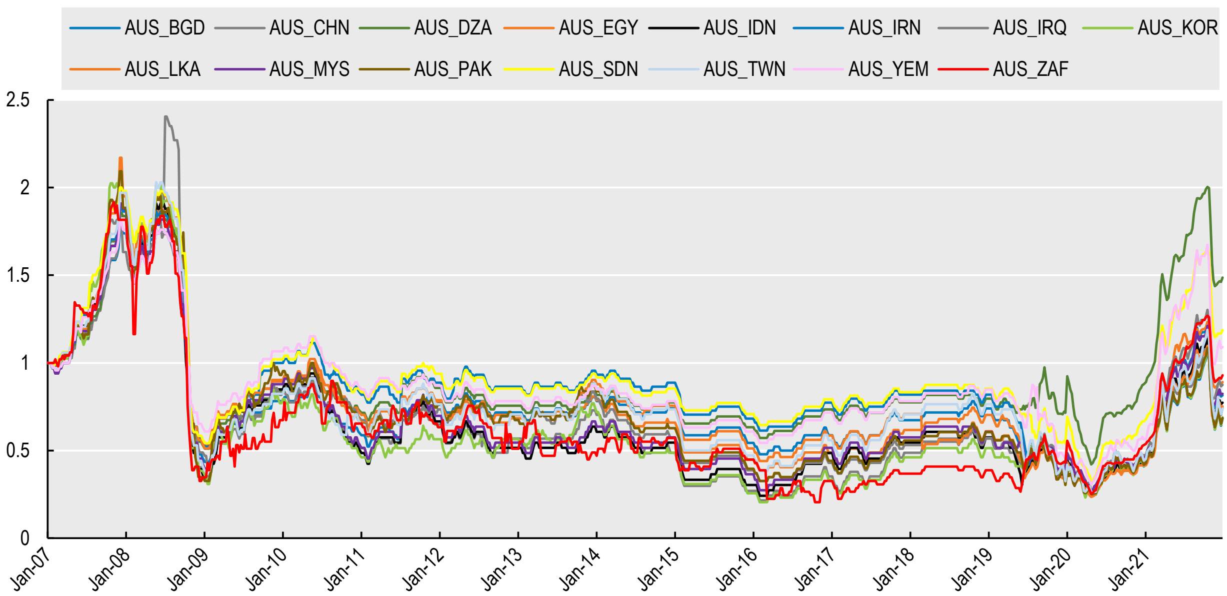
Annex A. Long-term evolution of freight rates

Figure A A.1. Long-term evolution of freight rates for HSS cargoes originating from Argentina, January 2007 – December 2021 (January 2007=1)



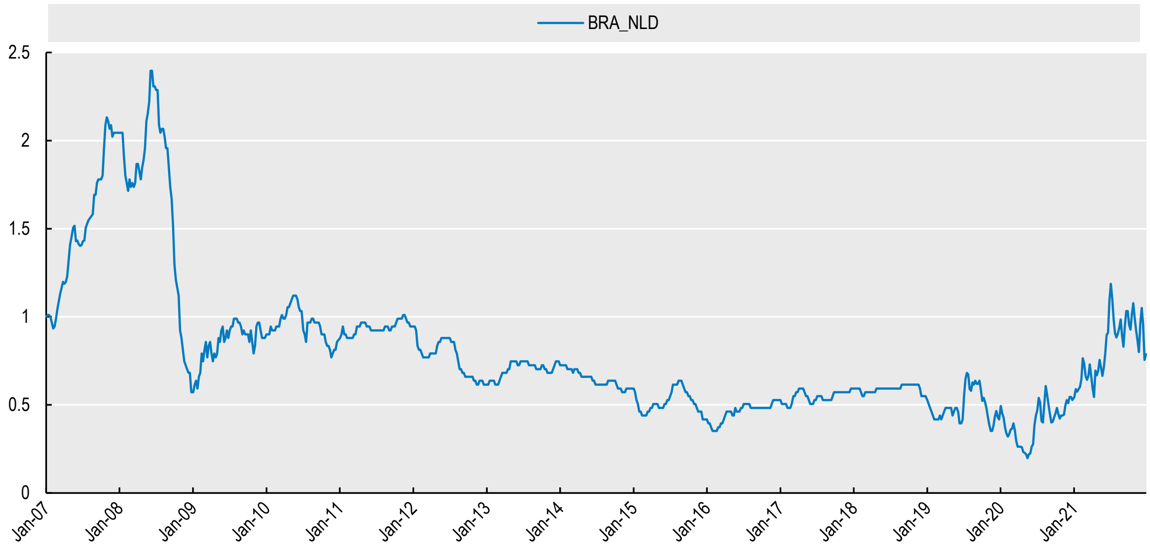
Source: Authors' calculations based on IGC (2022[2]).

Figure A A.2. Long-term evolution of freight rates for HSS cargoes originating from Australia, January 2007 – December 2021 (January 2007=1)



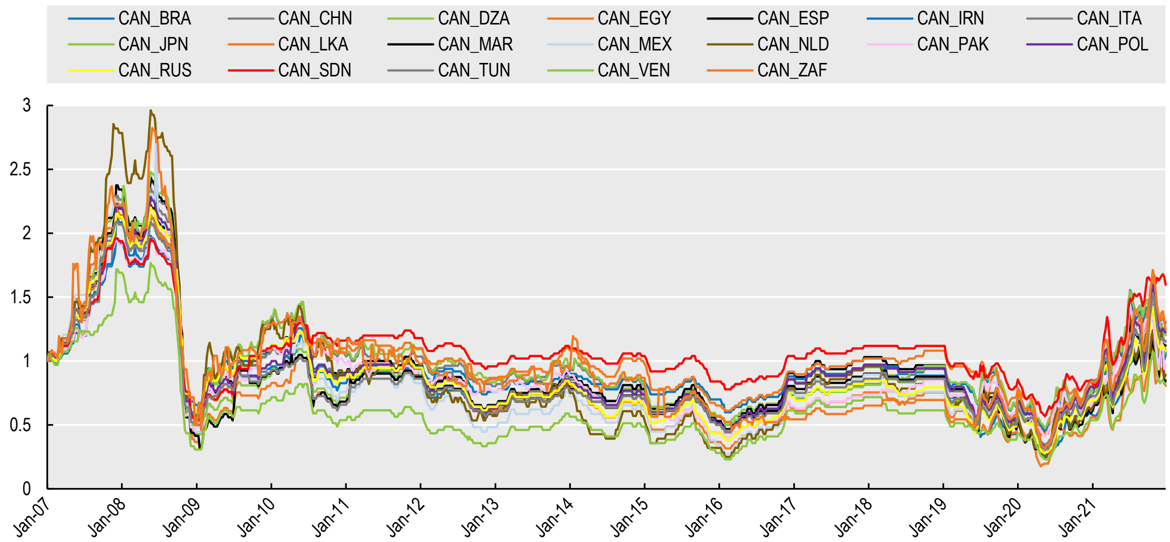
Source: Authors' calculations based on IGC (2022[2]).

Figure A A.3. Long-term evolution of freight rates for HSS cargoes originating from Brazil, January 2007 – December 2021 (January 2007=1)



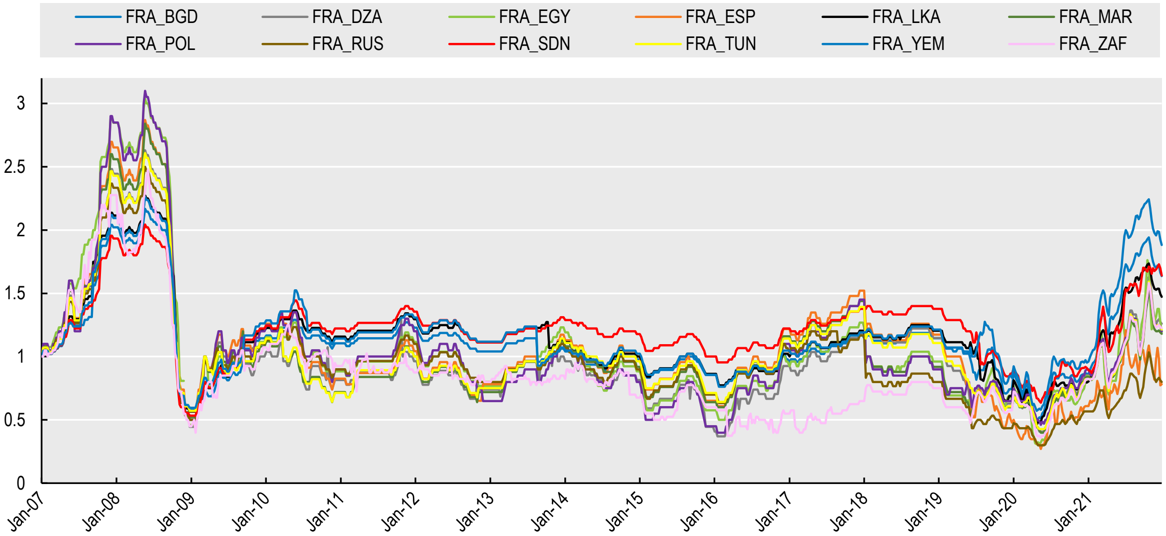
Source: Authors' calculations based on IGC (2022[2]).

Figure A A.4. Long-term evolution of freight rates for HSS cargoes originating from Canada, January 2007 – December 2021 (January 2007=1)



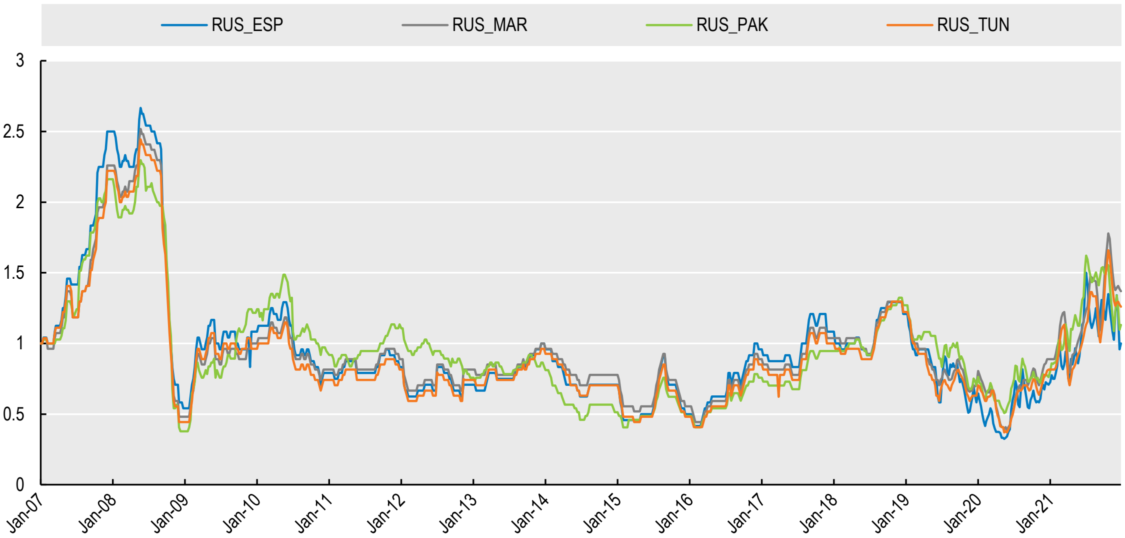
Source: Authors' calculations based on IGC (2022[2]).

Figure A A.5. Long-term evolution of freight rates for HSS cargoes originating from France, January 2007 – December 2021 (January 2007=1)



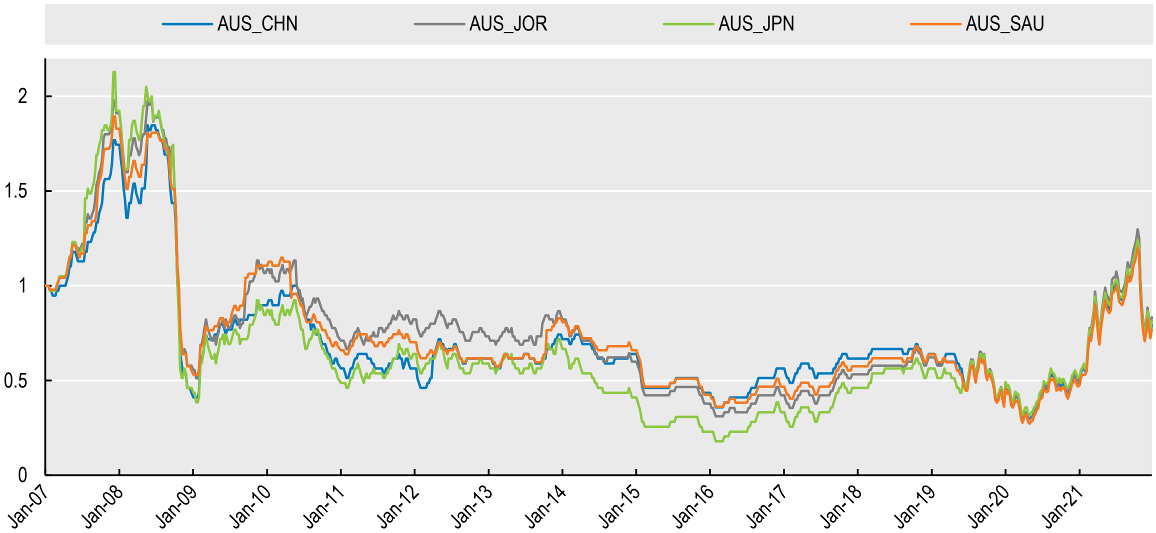
Source: Authors' calculations based on IGC (2022[2]).

Figure A A.6. Long-term evolution of freight rates for HSS cargoes originating from Russia, January 2007 – December 2021 (January 2007=1)



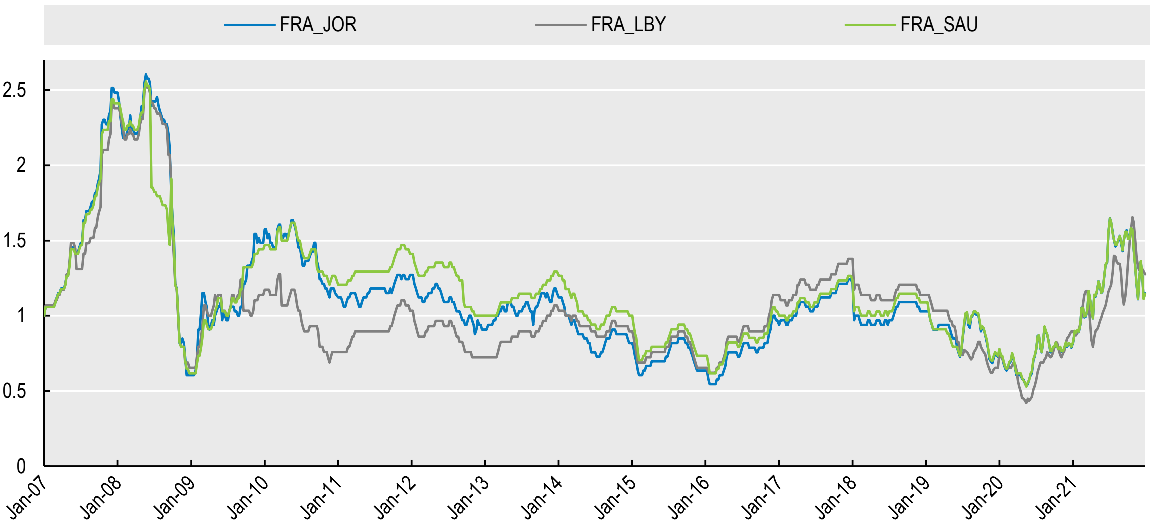
Source: Authors' calculations based on IGC (2022[2]).

Figure A A.7. Long-term evolution of freight rates for barley cargoes originating from Australia, January 2007 – December 2021 (January 2007=1)



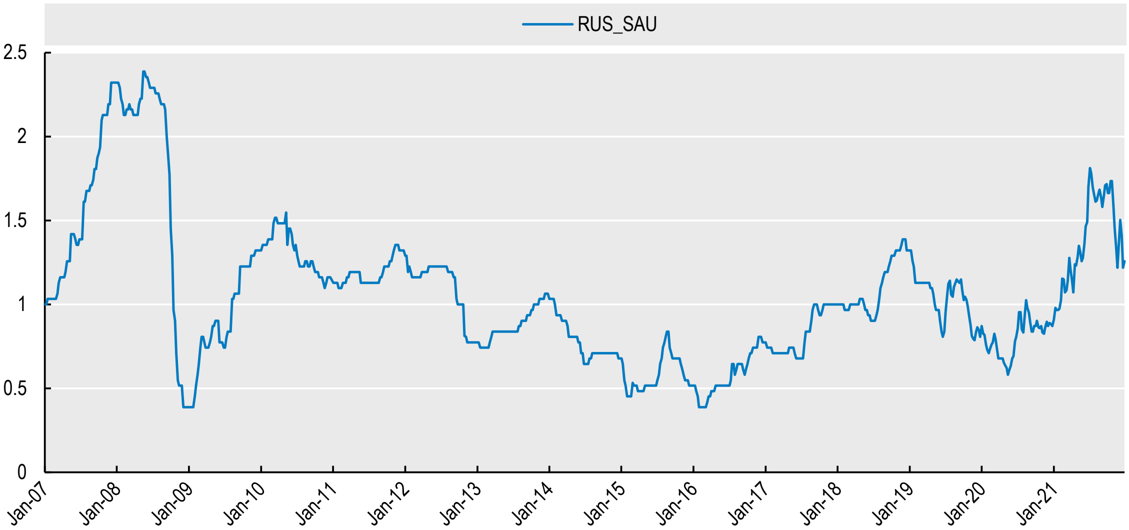
Source: Authors' calculations based on IGC (2022[2]).

Figure A A.8. Long-term evolution of freight rates for barley cargoes originating from France, January 2007 – December 2021 (January 2007=1)



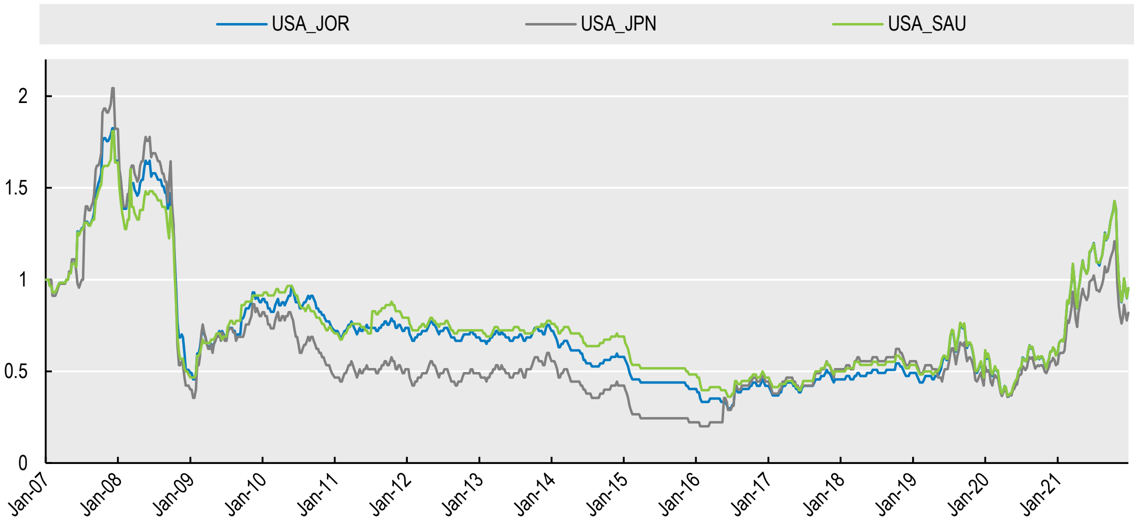
Source: Authors' calculations based on IGC (2022[2]).

Figure A A.9. Long-term evolution of freight rates for barley cargoes originating from the Russia, January 2007 – December 2021 (January 2007=1)



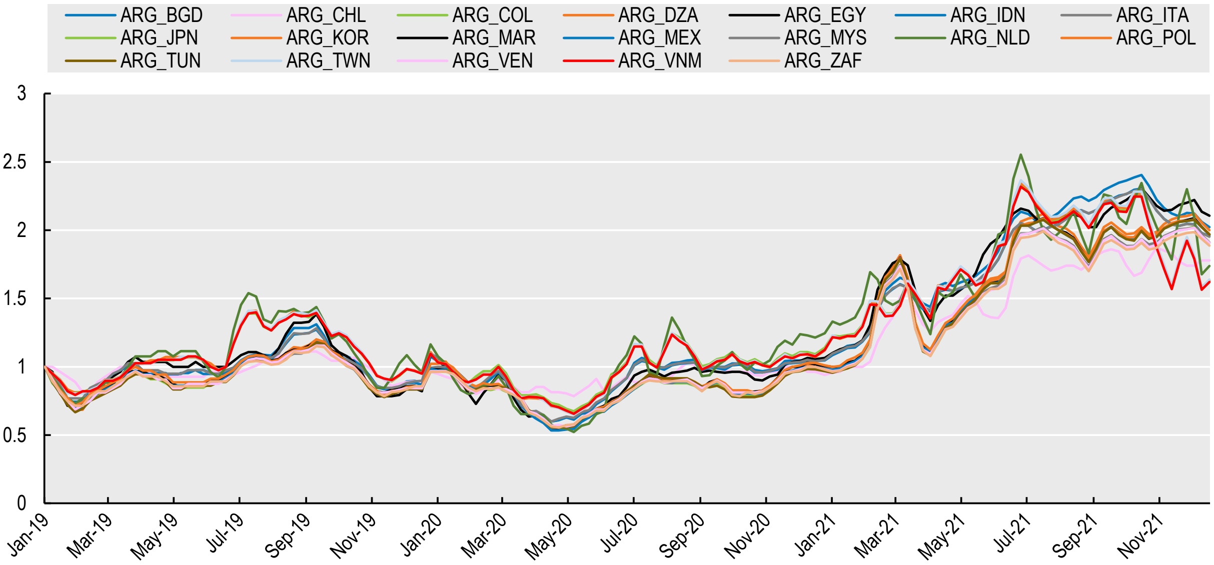
Source: Authors' calculations based on IGC (2022[2]).

Figure A A.10. Long-term evolution of freight rates for barley cargoes originating from the United States, January 2007 – December 2021 (January 2007=1)



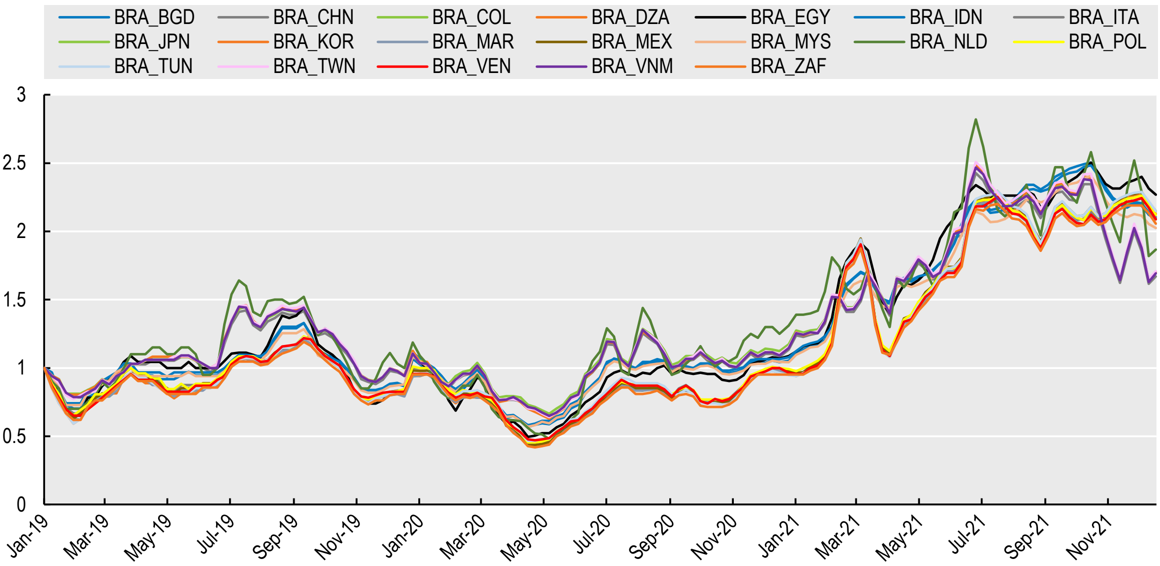
Source: Authors' calculations based on IGC (2022[2]).

Figure A A.11. Short-term evolution of freight rates for maize cargoes originating from Argentina, January 2019 – December 2021 (January 2019=1)



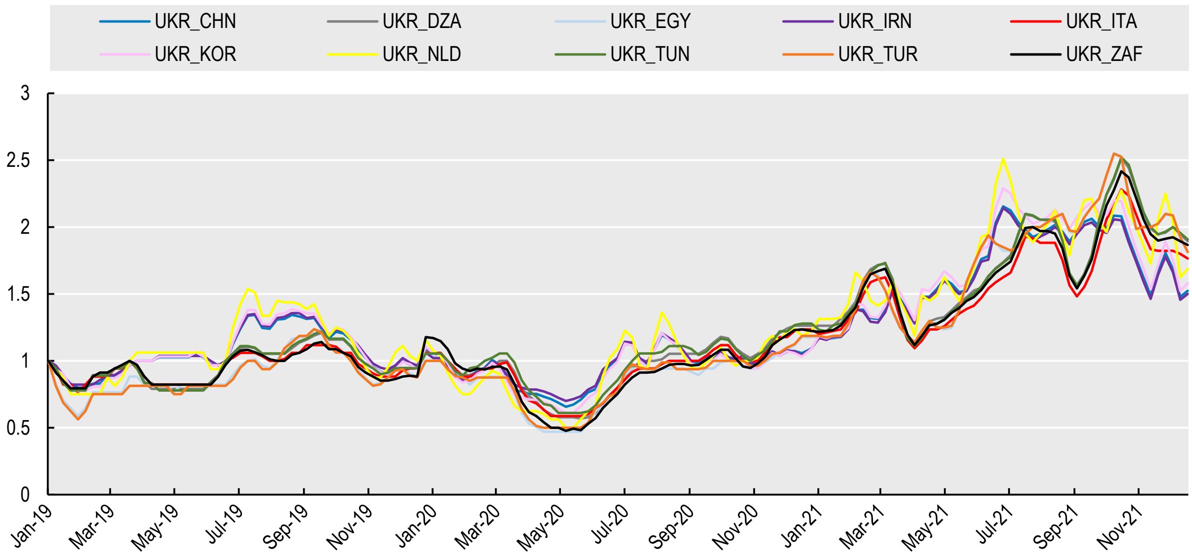
Source: Authors' calculations based on IGC (2022[2]).

Figure A A.12. Short-term evolution of freight rates for maize cargoes originating from Brazil, January 2019 – December 2021 (January 2019=1)



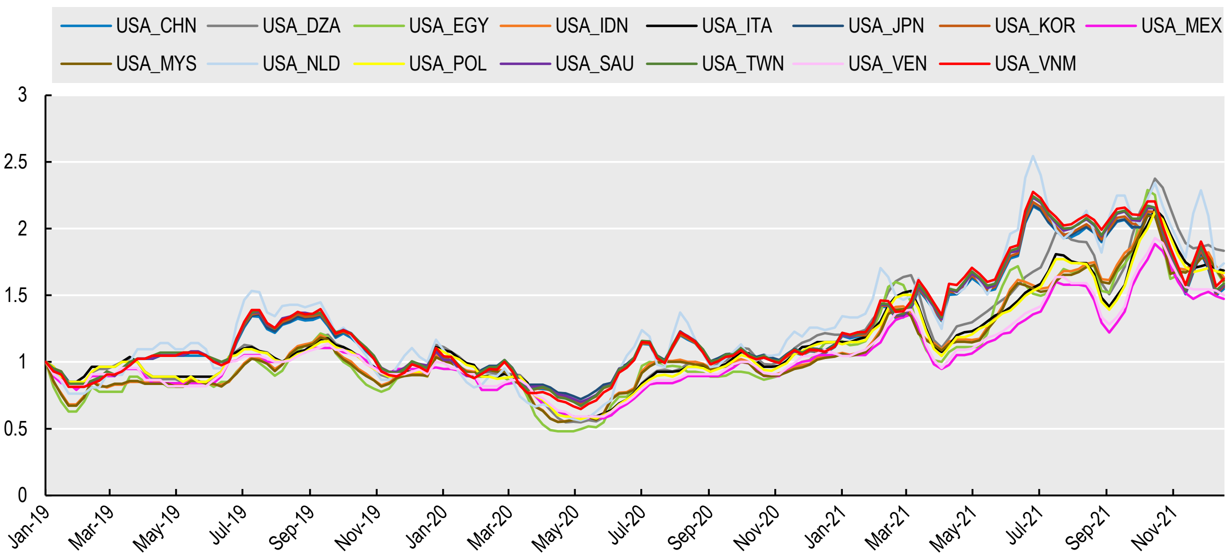
Source: Authors' calculations based on IGC (2022[2]).

Figure A A.13. Short-term evolution of freight rates for maize cargoes originating from Ukraine, January 2019 – December 2021 (January 2019=1)



Source: Authors' calculations based on IGC (2022[2]).

Figure A A.14. Short-term evolution of freight rates for maize cargoes originating from the United States, January 2019 – December 2021 (January 2019=1)



Source: Authors' calculations based on IGC (2022[2]).

Annex B. Robustness checks

To test whether the results are sensitive to certain model specifications or trends, several robustness checks were performed. Table A B.1 and Table A B.2 report the results of these robustness checks.

Whereas trade data are reported with monthly frequency, the data on freight rates and fob prices are reported at the weekly or daily level. Columns (1) and (2) in Table A B.1 test whether using daily data for freight rates and fob prices, and hence a larger database, affects the results for the short-term analysis. In this case, the short-term analysis covers the period July 2019-October 2021 since freight rates are only reported at the daily level from July 2019 onwards. Column (1) shows the regression results with the current fob price, while column (2) uses the one-month lagged fob price.

Columns (3) through (6) in Table A B.1 examine whether the results change if different fixed effects are used. That is, using exporter, importer and time fixed effects instead of interaction exporter-time and importer-time fixed effects. The robustness checks are performed for the long-term analysis at the monthly level (columns (3) and (4)) and for the short-term analysis at the daily level (columns (5) and (6).

Table A B.2 checks the robustness of the results if three interaction fixed effects are used, namely exporter-time, importer-time and commodity-time fixed effects. The regressions are run using monthly data for the long term (columns (1) and (2)) and short term (columns (3) and (4)), and using daily data for the short term (columns (5) and (6)).

Results from the different robustness checks confirm the results in the original model specifications (Table 4). More specifically, in the long-term and short-term analysis, the coefficient of quantity traded is not statistically significant, whereas the coefficient on distance is statistically significant. The size of the coefficient on distance corresponds with the main results and implies that a 10% increase in bilateral distance between ports is associated with an increase of around 2.5% in the freight rates. Estimates from the different specifications confirm that the iceberg assumption can be rejected at the 1% significance level in all the cases, underlining that maritime transportation costs in the grains and oilseeds sector are additive and not ad-valorem. The different specifications in the robustness checks also confirm that the current and one-month lagged fob price has no significant impact on the freight rate in the long-term analysis, but has a significant impact in the short-term analysis.

The regressions are also run using only the UN Comtrade trade data but results are not shown because the number of observations dropped significantly.

Table A B.1. Robustness checks: Daily data and no interaction fixed effects

	Short term (07.2019-10.2021)	Short term (07.2019-10.2021)	Long term (01.2010-10.2021)	Long term (01.2010-10.2021)	Short term (07.2019-10.2021)	Short term (07.2019-10.2021)
	(1)	(2)	(3)	(4)	(5)	(6)
ln(fob)	-0.0623***		-0.0140		-0.185**	
	(0.0107)		(0.0238)		(0.0448)	
L.ln(fob)		-0.0643***		-0.0257		-0.185**
		(0.00935)		(0.0250)		(0.0494)
ln(distance)	0.264***	0.263***	0.247**	0.242**	0.265***	0.265***
	(0.0359)	(0.0362)	(0.0431)	(0.0430)	(0.0375)	(0.0385)
ln(traded quantity)	0.000297	0.000218	-0.000144	-0.000256	0.00100	0.000740
	(0.00249)	(0.00258)	(0.00203)	(0.00196)	(0.00239)	(0.00262)
Constant	1.372**	1.395**	1.225	1.332*	2.030***	2.046**
	(0.310)	(0.355)	(0.536)	(0.542)	(0.355)	(0.514)
Exporter-time fixed effects	YES	YES	NO	NO	NO	NO
Importer-time fixed effects	YES	YES	NO	NO	NO	NO
Exporter fixed effects	NO	NO	YES	YES	YES	YES
Importer fixed effects	NO	NO	YES	YES	YES	YES
Commodity fixed effects	YES	YES	YES	YES	YES	YES
Time fixed effects	YES	YES	YES	YES	YES	YES
Frequency	Daily	Daily	Monthly	Monthly	Daily	Daily
Observations	95,950	90,145	8,315	8,151	99,505	93,483
R-squared	0.957	0.957	0.862	0.861	0.930	0.931
F-stat ($\beta_1 = 1$)	9780	12964	1815	1682	699.8	574.8
p-stat	0.00	0.00	0.00	0.00	0.00	0.00

Note: *** p<0.01, ** p<0.05, * p<0.1. Standard errors are clustered at the exporter-importer-commodity triplet to correct for potential correlation of errors across these triplets.

Table A B.2. Robustness checks: Three interaction fixed effects with monthly and daily data

	Long term	Long term	Short term	Short term	Short term	Short term
	(01.2010-10.2021)	(01.2010-10.2021)	(01.2019-10.2021)	(01.2019-10.2021)	(07.2019-10.2021)	(07.2019-10.2021)
	(1)	(2)	(3)	(4)	(5)	(6)
ln(fob)	-0.130		-0.110***		-0.0801*	
	(0.131)		(0.0119)		(0.0331)	
L.ln(fob)		-0.121		-0.118**		-0.100***
		(0.139)		(0.0277)		(0.0144)
ln(distance)	0.223**	0.215*	0.258***	0.261***	0.263***	0.262***
	(0.0515)	(0.0527)	(0.0395)	(0.0459)	(0.0355)	(0.0365)
ln(traded quantity)	0.000784	0.000492	-0.000139	-0.000224	0.000379	0.000245
	(0.00249)	(0.00266)	(0.00211)	(0.00203)	(0.00242)	(0.00286)
Constant	2.094	2.111	1.647***	1.677***	1.473**	1.599***
	(1.199)	(1.273)	(0.297)	(0.263)	(0.375)	(0.325)
Exporter-time fixed effects	YES	YES	YES	YES	YES	YES
Importer-time fixed effects	YES	YES	YES	YES	YES	YES
Commodity-time fixed effects	YES	YES	YES	YES	YES	YES
Exporter fixed effects	NO	NO	NO	NO	NO	NO
Importer fixed effects	NO	NO	NO	NO	NO	NO
Commodity fixed effects	NO	NO	NO	NO	NO	NO
Time fixed effects	YES	YES	YES	YES	YES	YES
Frequency	Monthly	Monthly	Monthly	Monthly	Daily	Daily
Observations	7,178	6,996	5,540	5,358	95,948	90,141
R-squared	0.944	0.945	0.952	0.953	0.957	0.958
F-stat ($\beta_1 = 1$)	74.32	64.86	8672	1629	1063	5812
p-stat	0.0132	0.0151	0.00	0.00	0.00	0.00

Note: *** p<0.01, ** p<0.05, * p<0.1. Standard errors are clustered at the exporter-importer-commodity triplet to correct for potential correlation of errors across these triplets.

Annex C. Hub and authority centrality for all ports by cargo

Table A C.1. Hub centrality for origin countries – six month averages 2020-2021

HSS

	JanJun2020	JulDec2020	JanJun2021	JulDec2021
Argentina	0.30	0.32	0.31	0.30
Australia	0.30	0.32	0.25	0.28
BRA Itaqui	0.01	0.10	0.11	0.12
BRA Santos	0.38	0.38	0.35	0.33
Canada	0.44	0.42	0.43	0.43
France	0.34	0.32	0.35	0.35
GBR Tilbury	0.12	0.10	0.12	0.13
Germany	0.01	0.01	0.02	0.02
RUS Novorossiysk	0.32	0.31	0.32	0.32
Romania	0.01	0.01	0.01	0.01
USA NewOrleans	0.35	0.36	0.38	0.39
USA Tacoma	0.12	0.14	0.11	0.12
Ukraine	0.32	0.32	0.33	0.33

Maize

	JanJun2020	JulDec2020	JanJun2021	JulDec2021
Argentina	0.44	0.46	0.44	0.43
BRA Itaqui	0.00	0.16	0.19	0.18
BRA Santos	0.61	0.61	0.55	0.51
Romania	0.04	0.03	0.04	0.05
USA NewOrleans	0.42	0.41	0.46	0.50
USA Tacoma	0.18	0.18	0.17	0.20
Ukraine	0.47	0.43	0.47	0.48

Barley

	JanJun2020	JulDec2020	JanJun2021	JulDec2021
Australia	0.66	0.63	0.44	0.46
France	0.47	0.48	0.41	0.39
GBR Tilbury	0.32	0.35	0.63	0.63
RUS Novorossiysk	0.27	0.29	0.26	0.25
USA Tacoma	0.36	0.37	0.27	0.28
Ukraine	0.17	0.17	0.17	0.17

Note: For countries with two ports in the IGC database, the country name is represented by the ISO3 code and the name of the port is specified.
Source: Authors' calculations based on IGC (2022[2]).

Table A C.2. Authority centrality for destination countries – six month averages 2020-2021

HSS

	JanJun2020	JulDec2020	JanJun2021	JulDec2021
Algeria	0.17	0.17	0.16	0.16
Angola	0.03	0.03	0.04	0.04
BRA Santos	0.12	0.13	0.13	0.12
Bangladesh	0.14	0.15	0.14	0.14
Chile	0.06	0.06	0.08	0.07
China	0.15	0.16	0.15	0.17
Chinese Taipei	0.09	0.09	0.08	0.09
Colombia	0.14	0.15	0.15	0.15
Djibouti	0.04	0.05	0.05	0.05
Egypt	0.30	0.30	0.28	0.28
GBR Liverpool	0.08	0.07	0.08	0.09
Ghana	0.09	0.08	0.08	0.08
India	0.07	0.07	0.07	0.08
Indonesia	0.18	0.19	0.18	0.18
Iran	0.14	0.14	0.14	0.16
Iraq	0.06	0.07	0.06	0.06
Italy	0.20	0.21	0.22	0.21
Japan	0.12	0.13	0.12	0.13
Kenya	0.13	0.13	0.14	0.13
Korea	0.18	0.18	0.17	0.19
Libya	0.04	0.03	0.04	0.04
Malaysia	0.05	0.05	0.04	0.05
Mexico	0.14	0.16	0.16	0.16
Morocco	0.22	0.22	0.22	0.22
Netherlands	0.21	0.20	0.20	0.21
Nigeria	0.14	0.13	0.13	0.13
OMN PortSultanQaboos	0.18	0.19	0.19	0.18
OMN Salalah	0.19	0.20	0.19	0.19
Pakistan	0.16	0.16	0.16	0.16
Poland	0.16	0.17	0.18	0.18
RUS Baltiysk	0.17	0.17	0.17	0.17
South Africa	0.22	0.22	0.20	0.20
Spain	0.33	0.29	0.31	0.33
Sri Lanka	0.09	0.10	0.09	0.10
Sudan	0.11	0.12	0.11	0.10
Tunisia	0.20	0.20	0.22	0.21
Turkey	0.26	0.25	0.25	0.23
Venezuela	0.14	0.15	0.15	0.14
Vietnam	0.12	0.12	0.12	0.12
Yemen	0.05	0.05	0.05	0.05

Maize

	JanJun2020	JulDec2020	JanJun2021	JulDec2021
Algeria	0.27	0.25	0.25	0.24
Bangladesh	0.10	0.09	0.08	0.08
Chile	0.05	0.06	0.07	0.06
China	0.15	0.15	0.16	0.18
Chinese Taipei	0.15	0.15	0.14	0.16
Colombia	0.15	0.16	0.14	0.12
Egypt	0.33	0.30	0.30	0.29
GBR Liverpool	0.18	0.15	0.19	0.21
Indonesia	0.14	0.14	0.14	0.13
Iran	0.05	0.05	0.06	0.06
Italy	0.30	0.32	0.34	0.33
Japan	0.14	0.14	0.14	0.16
Korea	0.20	0.20	0.20	0.22
Malaysia	0.16	0.16	0.15	0.16
Mexico	0.22	0.25	0.26	0.25
Morocco	0.16	0.16	0.13	0.12
Netherlands	0.35	0.32	0.34	0.36
OMN PortSultanQaboos	0.20	0.21	0.20	0.19
OMN Salalah	0.20	0.22	0.21	0.20
Poland	0.19	0.22	0.22	0.21
Saudi Arabia	0.04	0.04	0.04	0.05
South Africa	0.23	0.23	0.21	0.19
Tunisia	0.22	0.22	0.22	0.20
Turkey	0.12	0.09	0.11	0.10
Venezuela	0.22	0.23	0.23	0.22
Vietnam	0.15	0.15	0.15	0.17

Barley

	JanJun2020	JulDec2020	JanJun2021	JulDec2021
Algeria	0.11	0.12	0.23	0.22
China	0.38	0.37	0.27	0.28
GBR Liverpool	0.06	0.06	0.06	0.06
Japan	0.35	0.34	0.22	0.24
Jordan	0.42	0.41	0.29	0.29
Libya	0.27	0.26	0.20	0.19
Netherlands	0.16	0.19	0.39	0.41
OMN PortSultanQaboos	0.16	0.18	0.15	0.14
OMN Salalah	0.17	0.19	0.16	0.14
Saudi Arabia	0.60	0.61	0.57	0.56
Spain	0.14	0.15	0.30	0.30

Note: For countries with two ports in the IGC database, the country name is represented by the ISO3 code and the name of the port is specified.
Source: Authors' calculations based on IGC (2022[2]).

Annex D. Routes by exporter

Table A D.1. Number of routes covered by exporter and cargo in the long-term and short-term analysis

	Long term		Short term		
	Barley	HSS	Barley	HSS	Maize
Argentina		13		25	19
Australia	4	15	5	18	
Brazil		1		23	19
Canada		19		32	
France	3	12	4	20	
Russia	1	4	2	18	
United States	3	23	3	33	15
Ukraine				18	10

Annex E. Countries and ports

Table A E.1. Country and port names, by cargo and importer/exporter status

Country	Port	HSS	Maize	Barley	Importer	Exporter
Argentina	Rosario	x	x			x
Australia	Kwinana	x		x		x
Brazil	Itaqui	x	x			x
Brazil	Santos	x	x			x
Canada	Baie-Comeau	x				x
France	Rouen	x	x	x		x
Germany	Hamburg	x				x
India	Kakinada					x
Pakistan	Karachi					x
Romania	Constanta	x	x			x
Russia	Novorossiysk	x		x		x
Thailand	Bangkok					x
Ukraine	Yuzhny	x	x	x		x
United Kingdom	Tilbury	x		x		x
United States	NewOrleans	x	x			x
United States	Tacoma	x	x	x		x
Algeria	Bejaia	x	x	x	x	
Angola	Luanda	x			x	
Bangladesh	Chittagong	x	x		x	
Benin	Cotonou				x	
Brazil	Santos	x			x	
Cameroon	Douala				x	
Chile	SanVicente	x	x		x	
China	Dalian	x	x	x	x	
Chinese Taipei	Kaohsiung	x	x		x	
Colombia	Barranquilla	x	x		x	
Cote D'Ivoire	Abidjan				x	
Djibouti	Djibouti	x			x	
Egypt	Alexandria	x	x		x	
Ghana	Tema	x			x	
Guinea	Conakry				x	
Guinea Bissau	Bissau				x	
India	Kandla	x			x	
Indonesia	Jakarta	x	x		x	
Iran	BandarAbbas	x	x		x	
Iraq	Basrah	x			x	

Country	Port	HSS	Maize	Barley	Importer	Exporter
Italy	Genoa	x	x		x	
Japan	Yokohama	x	x	x	x	
Jordan	Aqaba			x	x	
Kenya	Mombasa	x			x	
Korea	Inchon	x	x		x	
Liberia	Monrovia				x	
Libya	Tripoli	x		x	x	
Madagascar	Toamasina				x	
Malaysia	PasirGudang	x	x		x	
Mexico	Veracruz	x	x		x	
Morocco	Casablanca	x	x		x	
Mozambique	Maputo				x	
Netherlands	Rotterdam	x	x	x	x	
Nigeria	Lagos	x			x	
Oman	PortSultanQaboos	x	x	x	x	
Oman	Salalah	x	x	x	x	
Pakistan	Karachi	x			x	
Poland	Gdynia	x	x		x	
Russia	Baltiysk	x			x	
Saudi Arabia	Jeddah		x	x	x	
Senegal	Dakar				x	
Somalia	Mogadishu				x	
South Africa	Durban	x	x		x	
Spain	Cartagena	x	x	x	x	
Sri Lanka	Colombo	x			x	
Sudan	PortSudan	x			x	
Tanzania	DarEsSalaam				x	
Thailand	KohSichang	x			x	
Togo	Lome				x	
Tunisia	Bizerte	x	x		x	
Turkey	Canakkale	x	x		x	
United Kingdom	Liverpool	x	x	x	x	
Venezuela	PuertoCabello	x	x		x	
Viet Nam	HoChiMinhCity	x	x		x	
Yemen	Saleef	x			x	

OECD FOOD, AGRICULTURE AND FISHERIES PAPERS

This report was declassified by the Joint Working Party on Agriculture and Trade in June 2022 and was prepared for publication by the OECD Secretariat.

This report, as well as any data and any map included herein, are without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

The statistical data for Israel are supplied by and under the responsibility of the relevant Israeli authorities. The use of such data by the OECD is without prejudice to the status of the Golan Heights, East Jerusalem and Israeli settlements in the West Bank under the terms of international law.

Comments are welcome and can be sent to tad.contact@oecd.org.

© OECD (2022)

The use of this work, whether digital or print, is governed by the Terms and Conditions to be found at http://www.oecd.org/termsandconditions.