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Supply chain inefficiencies: the causes and costs of dry bulk ships anchored in Vancouver

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Abstract

The paper describes the contracting and logistics conditions contributing to the level of anchorage in the grain, coal and fertiliser export trades of Vancouver. Increases in the level of anchorage in these trades have created economic, environmental and governance issues. Comparison of the logistics structures and practices in these commodity trades gives insights into the reasons for different levels of anchorage. Conditions in and data from the port of Vancouver are used to simulate conditions in the grain trade and to demonstrate the critical importance of the variability of ship loading times to levels of anchorage. The incidence of the costs of anchorage is examined. The terms in voyage charterparties used in the grain trade are found to inhibit efficient use of vessel time.

Keywords: Anchorage, Export logistics, Loading rates, Shipping terms, Virtual arrival, Grain

Introduction

The anchorage of ships in the dry bulk trades through the port of Vancouver, Canada, has become costly and controversial as it has expanded beyond the port's waters. This paper reviews the major causes and costs of the anchorage of those ships. The purpose is to provide information and perspectives that may contribute to the evolution of private and public policies and practices that ameliorate the need for undue waiting time of ships in Vancouver and elsewhere.

The paper is in six further sections. The growing significance of anchorage in Vancouver and the general ship types involved are outlined in the next section. In section three, the trades that dominate anchorage (grain, coal and fertiliser)[1] are examined more closely and simulation is used to test the significance of variability of loading rates for grain. Factors that may account for the variability are outlined in the fourth section. In

[1] As is common, these trades are identified by singular nouns, but each is composed of multiple specific products.

the fifth section, the nature and distribution of the environmental and economic costs of anchorage which affect efficient outcomes are examined. Section six is a summary of the challenges to and opportunities of reducing anchorage in Vancouver. These may have relevance elsewhere. The paper concludes by identifying questions for further research.

The analysis of the port anchorage data is limited by the confidentiality of corporate information. The details of shipping contracts are unknown so that the implications of voyage and time charter contracts cannot be tested statistically although their significance can be inferred from general knowledge of their incidence. Also, the time that ships are anchored for bunkering, vessel inspection or vessel cleaning is not known. However, our expectation that the effects of these activities on the duration of anchorages is minimal is confirmed by shipping agents.

We hope that our analysis and observations will raise interest and sharpen focus on issues associated with ship anchorage levels in bulk export trades beyond Vancouver. However, an element largely absent in the Vancouver trades is holding product inventory in port or on ships to optimise market timing, as is common in oil trades, especially at discharge ports.

The conditions in Vancouver

The 'anchorage problem' in Vancouver has been growing for well over a decade. Prior to 2016, the port authority in Vancouver, now the Vancouver Fraser Port Authority (VFPA), worked with ships agents so that when anchorage availability in the port was limited, ships needing to wait at anchor for a week would anchor outside the port in the Southern Gulf Islands (SGI), some 40 to 60 nautical miles distant, Fig. 1. Anchorage in these waters falls under federal administration, Transport Canada (TC). Continued increase in the pressure on the VFPA's 28 anchorages led to the formal introduction of the 7-day rule in 2016. By this rule, a ship may be limited to seven consecutive days at anchor within the port. The demand on anchorages continued to increase and complaints from residents in the sensitive environment of the SGI increased. On February 8, 2018, after lengthy consultations under TC's Ocean Protection plan, the Interim Protocol for the use of Southern British Columbia Anchorages was issued by TC. It involved an extension of VFPA's responsibility to assign ships to anchorages in SGI waters so that utilisation among the anchorages in SGI is balanced. The Protocol is still in effect.[2] In 2020, MP Alistair MacGregor tabled a Private Member's Bill C-250 in the House of Commons in Ottawa to ban the anchoring of freighters in SGI and adjacent Vancouver Island waters. The Bill did not advance. In 2021, an Active Vessel Traffic Management initiative (AVTM) was commenced, led by VFPA and TC, (TC 2021). It has involved extensive discussions with industry and citizens groups. A visible result from the program is the issuance for discussion of a draft anchorage code of conduct and an approach to information sharing and complaint resolution (VFPA 2022).

In spite of the obvious long-lasting concern about anchorage, surprising little information is public about the actual levels or the reasons that ship are waiting. Establishing as many facts as possible about the level of anchorage must precede an examination of the conditions accounting for them.

[2] Real time data on the ships anchored in SGi is at https://patbaywebcam.com/anchorage.php.

Fig. 1 Anchorages in Southern BC

An Anchorage Working Group formed by TC and VFPA in 2017, needed documentation. It was developed by TC using billing records of the Pacific Pilotage Authority (PPA). The resulting unpublished statistics are the only comprehensive quantitative data for all ship types and for ships anchored in VFPA and SGI waters. Over the period 2013 to 2018, three export commodities were found to dominate: grain accounted for 48.6% of anchor time, coal and potash 31.8%[3] (Transport Canada 2018). Consequently, research for this paper has concentrated on the grain, coal and fertiliser trades.

Two sources of data are used to identify key characteristics of the grain, coal and fertiliser trades. The first is a confidential file of ship movement and commodity data provided for this research by VFPA. The second is the report of Rohner and Fullerton (2020) who, like TC, use data of PPA down to the berth level thereby enabling full recognition of cargoes. The combination of data from these sources enables the quantification of

[3] Coal and potash trades could not be separated because terminal calls by ships were used to track ship movements, not berth calls; a major terminal handles these commodities at separate berths. The diverse import and export trade of mineral concentrates accounted for the next most anchorage time, 7.8%.

Table 1 Ships, average cargo, anchorage and berth time by commodity, 2015–2018

	Grain	Coal	Fertilisers
Av annual # ships[a]	483	336	210
Average ship cargo[a]	46,113 tonnes	105,892	51,283
Av. berth days[a]	4.3	2.6	2.9
Av. anchor days[b]	10.0	6.9	3.7
Av year anchor days[c]	4830	2318	777

[a] Own calculation based on VFPA data by correspondence

[b] Rohner and Fullerton, 2020 and by correspondence

[c] VFPA number of ships multiplied by Rohner and Fullerton average anchor days

the grain, coal and fertiliser trades and the aggregate anchorage levels in VFPA and SGI waters for 2015–2018, Table 1.

The table shows that for each commodity, ships spend more time on average at anchor than they do on berth per port call.[4] However, there are significant variations in the incidence of anchorage by commodity. These differences remain comparable under annual variations caused by weather, labour issues and traffic volumes. The grain trade employs the largest number of ships and those ships are at anchor and on the berth for the longest average times. The trade with the least time at anchor is the fertiliser group; potash is consistently over 70% of this group.

While the averages in Table 1 capture the essential differences between the commodities in average cargo tonnage (and implied ship size), berth and anchor times, they do not capture the dynamic conditions that give rise to the need for anchorage. Therefore, the VFPA data was examined to identify key features of the commodity trades and was used to construct a simulation model to investigate key differences among the trades and their key dynamics.

Loading rate variability as a driver of anchorage

Given that the use of anchorages is dependent on the rate of ship arrivals and the time to service them before their departure, the examination of the VFPA data focused on the pattern of ship arrivals and the rate at which they could be loaded.

Broadly similar Poisson distributions were found for ships arrivals for the commodities throughout the year and are comparable across the commodities. However, the distribution of inter-arrival times for fertilizers is more symmetric and without a long "tail", suggesting arrivals that are more "scheduled".

The inter-arrival times of ships varies not just because of loading performances in previous ports and weather conditions at sea. Even if arrivals were to be perfectly predictable, they are not coordinated and thus would appear random. It is particularly uncertain for bulk ships which have long loading and unloading times. In the case of ships on voyage charters, there is leeway in the arrival date provided by the laycan period, that is first and last date between which a ship is required to provide its Notice of Readiness (NOR) to load. For grain contracts, it is commonly 10 days. Once NOR is effective, the loading terms of the charter become effective.

[4] The present tense is used for the data as current conditions are essentially unchanged.

Table 2 Ship loading times per stop, 2014–2019

Group[a]	Definition	Percent (%)	Mean (days)	SD (days)	Coeff Var
Grain low	< 45,000 tonnes	66	2.62	2.42	0.92
Grain medium	> 45,000 tonnes	34	4.16	3.54	0.85
Fertiliser low	< 45,000 tonnes	43	1.7	1.14	0.67
Fertiliser med	> 45,000 tonnes	57	3.13	1.76	0.56
Coal	LOA < 260 mts	59	1.98	0.89	0.45
Coal long	LOA > 260 mts	41	3.06	1.41	0.46

[a] Commodity groups are subdivided tonnage loaded per terminal stop or by overall ship length (LOA)

The ability of terminals to service ships is dependent on the berth capacity utilisation, the availability of the cargo, the duration of loading and the tonnage loading rate. Ships may be on berth prior to, during and after actual loading for other activities. For this research, the only data available are the cargo loaded per stop and the time that a ship is on berth per stop, so the loading times shown here are approximations.[5]

Table 1 shows that more time is required to load (smaller) grain ships than (larger) coal ships. However, the important feature for logistics planning and avoidance of ships at anchor is the variability in loading times. Therefore, the VFPA data were examined to identify the variability (coefficient of variability) of loading times per stop by commodity and by cargo or ship size, Table 2. The variability of loading time is greater for grain than for either coal or fertiliser. The loading time distribution was found to be the same per stop irrespective of the number of stops. For grain ships, 55% and 13% have second and third stops respectively, fertiliser 40% have a second stop and coal only 10%.

The significance of the variability in the loading time of grain for the level of anchorage was tested using a simulation model in Arena©. The model is for a generic port but with attributes built on the characteristics of the facilities for the grain, coal and fertiliser trades of Vancouver. Because of the concern with the spillover anchorage in SGI, the anchorages are divided into those available in an inner harbour, IH, (Vancouver) and those in an outer harbour, OH, (SGI).

IH has a capacity of 14 standard anchorages and 4 anchorages available for long ships, 260 m plus length overall (LOA). The OH is not capacitated and is used essentially as a spillover, except that the VFPA's 7-day rule requiring a ship to vacate IH is uniformly applied. The arrival of ships is simulated with the established Poisson arrival rates. They are assigned to anchorages in IH if an adequate one is available, otherwise they are assigned to OH. The total need for anchorage is unaffected by the number of ships waiting or by their assignment. Ships are moved only when an empty berth becomes available except for the operation of the 7-day rule. Ships have a loading priority based on their time of arrival.[6] The loading priority is not affected by the 7-day rule.

A 'Base' simulation model was run using the arrival and loading time distributions of the 2014–2019 data. Then, a percentage of the longest grain loading times was removed, resulting in the mean and standard deviation, both now smaller, being recalculated to generate a new distribution for the simulation. The ship arrivals are unchanged in both number and mix. Table 3 shows the modelled average number of

[5] The arrival of a ship to the port is termed a 'call'; each visit to a terminal is called a 'stop'.

[6] In reality, terminals may call in ships out of their arrival (NOR) sequence.

Table 3 Average number ships at anchor with reduced extreme grain loading times (200 replications)

	G	G	C+F	C+F	Total	Total	Total	Total
	IH	OH	IH	OH	Non-G	IH	OH	All
Base	7.8	15.5	4.2	8.5	**12.7**	12.0	24.0	36.0
1%	5.8	5.6	6.0	7.6	**13.6**	11.8	13.2	24.9
2%	4.2	2.4	6.4	6.3	**12.7**	10.6	8.7	19.3
3%	3.2	1.1	6.5	5.6	**12.1**	9.7	6.6	16.3

grain (G), coal (C) and fertiliser (F) ships at anchor in IH and OH for the base case (shaded) and for different reductions of extreme loading times. The most aggressive reduction in the experiment is merely a 3% reduction of the longest grain loading times. This results in the long-term average number of grain ships at anchor in either IH or OH dropping from 23.3 (7.8 + 15.5) to 4.3 (3.2 + 1.1). The consequence of this is a reduction in the total number of ships in OH from 24.0 to 6.6. Some ships remain at OH anchorages even though IH anchorages are available because ships assigned to OH anchorages remain there until going to a terminal. This points to opportunities to reduce OH anchorage by reassigning ships from OH to IH for safety and environmental reasons.

A peculiarity in Table 3 is that the number of non-Grain ships at anchor (bolded) varies. It should be unaffected by the reduction in the number of grain ships at anchor. This is evidence that variations in the population of ships across the 200 simulation runs still results in the slight variations in the total of non-grain ships between 12.1 and 13.6. The non-grain ships are shown to benefit with greater use of IH anchorages which are utilised less by grain ships. As would be expected, the benefit from reducing loading times declines with each 1%. Thus, the first 1% alone reduces the total average anchorage from 36 to 24.9 or 31% and the OH anchorage alone from 24 to 13.2 or 45%.

It is important to observe that this experiment makes no other changes than to remove the longest grain loading times. It does not reflect the possibility that under congested conditions more loading shifts may be worked.

In effect, the experiment reduces demand for services (the sum of loading times, D) while keeping the supply of services (sum of berth capacities, S) fixed. So, the key ratio of the system load or utilization (L = D/S) is reduced. Under many supply operations with significant variability in both supply and demand, this system load is typically kept at about 80%. This facilitates accommodation to surges in demand and enables faster reduction in congestion should it develop. The model shows that by reducing the incidence of long loading times, peak levels of anchorage are reduced and more quickly eliminated so amplifying the reduction in total annual anchorage-days. The contributing factors to the variability of loading rates in Vancouver have relevance widely.

Factors accounting for differences in loading time variability

Many factors in the logistics of grain, coal and fertiliser exporting are related to the differences in loading time variability among the commodities. The factors range from inherent characteristics in commodity production to logistics strategies, including dealing with events such as rainfall during cargo loading. A brief review of these factors leads to suggestions for strategies to improve logistics performance.

Inherent spatial and temporal differences in commodity logistics

The geographical spread of grain production is in sharp contrast to the localised output of mine products. It gives rise to challenges in the allocation and management of railcars, even after significant consolidation and upsizing of country elevators in Canada. Country elevators and grain marketing are also in the hands of many companies although oversees sales are dominated by five major traders.[7] In contrast, Canadian coal exported through Vancouver is mined by a single company at a few mines. The fertiliser trade is dominated by potash and sulphur shipped from few locations, each commodity with coordinated logistics, most notably with Canpotex dominant in potash exports.

Shipment volumes of mined products are more predictable than grain. Sales of mined products are often in annual contracts with a range of monthly quantities. Consequently, outputs, inventory levels and rail requirements are managed with good, but certainly not perfect, knowledge of delivery requirements. For grain, actual supply, both regional and total, are uncertain until harvest is completed, with implications for export sales and logistics requirements.[8] Railways refine customer forecasts by "…review[ing] the five-year historical averages and the latest Statistics Canada predictions on production and carry-in for the upcoming year." (Canadian Pacific 2022) Unexpected bumper crops lead to shippers being unable to get their crops to ports as quickly as they want (Edmiston 2022a). Grain sales contracts are typically made some three months before expected delivery to a port, making grain logistics more challenging than that for mined products.

The ownership of logistics assets

The span of control exercised by companies over assets and operations is influenced by many factors. These include the opportunities for control and efficiencies and past practices. This is evident in the span of control in the grain, coal and fertiliser industries. The span is greatest in the fertiliser sector, especially potash, least in grain. Canpotex, by far the largest exporter of potash, meets its responsibilities for overseas sales through the ownership of a fleet of railcars, port terminals and dominantly C&F (delivered to a port) sales terms. It relies heavily on vessels on long-term time charters which enables control of vessel sailing speed in keeping with berth conditions. It is still exposed to the allocation of rail line capacity to its unit trains. The coal industry, reflecting the economies of scale and the relative ease of terminal inventory maintenance, commenced with a common user terminal. However, subsequently, the major coal exporter invested in its own terminal and is now increasing the share of its exports through that terminal. Coal is shipped in rail-owned dedicated sets of unit trains. Grain logistics, on the other

7 Traders include well-known names such as Cargill, Canadian corporations owned largely by global traders, Viterra (Glencore), G3 (Bunge), and independent Canadian companies Richardson, and Parrish & Heimbecker.

8 VFPA reports a 30% drop in grain export tonnage between 2020 and 2022.

hand, has evolved from an industry with limited involvement in logistics because of government—prescribed rail rates and export marketing through a Wheat Board (Dimmell 2021). Too often, the historic adversarial relationship between the railways and the grain industry is still present. Grain companies share general demand expectations with the railways and place weekly orders for grain railcars. This gives rise to issues over the actual number of cars made available, the fill rate. Inadequate railcar supply as well as unreliable service delivery are constant complaints. In recent years, some grain companies have initiated ownership of their own railcars and unit trains.

The number of SKUs

The number of different products (stock keeping units, SKUs) is crucial to the management of inventory in any logistics system. A very significant feature of the grain industry in Canada is the choice to have a price premium by maintaining multiple classes, grades and qualities of grains. For example, there are 10 classes of Western Wheat each of which has grades determines by attributes of samples (Canadian Grain Commission 2023). While some mixing of grades is possible to meet the specifics of a sales contract, many SKUs flow through the system. Specific rail deliveries are required to ensure terminal inventory to serve specific ships. Terminals are incentivised to have several ships at anchor to ensure that one is available that matches the grain on hand. Differences in product characteristics also exist in coals and fertilisers but they are much less than within grains. So, their terminals face less challenges maintaining terminal inventories.

The maintenance of adequate inventories of grain is affected by the capacity of the grain elevators and the reliability of railcar deliveries. Over the years, changes have been made in elevator systems but these have been more directed towards changes in handling rates of unloading railcars and loading ships than towards changes in storage capacity. Apart from the recent construction of new terminals, inventory levels have remained the same for many years (Quorum 2022).

One consequence of an insufficient inventory for a needed SKU is that a ship can be bumped from a terminal so that a ship needing another SKU can load. Moving the ship is less costly than having the terminal's loading capacity idle. This accounts for the much greater frequency of multiple stops in the grain trade (55%) than the fertiliser (40%) or coal (10%) trades.

The role of rail

Rail services are essential to the Canadian bulk trades because of the distance involved. This is reflected in the efforts of government to ensure monitoring rail performance in the grain trade and supply chains generally (Transport Canada 2023). However, while the physical challenges are distinctive to Canada, the logistics management challenge is universal: The need for coordination along the whole supply chain from the sales contract to the final product delivery. That is the framework of the International Task Force on Port Call Optimisation included in the *Just in Time Arrival Guide* of the International Maritime Organisation (IMO 2020). For Vancouver's bulk exports the focus of attention gravitates to rail service, especially for grain. The matters of the railcar fill rate at origin and the reliability of delivery at Vancouver have already been identified as important features of rail services for grain. The latter is directly linked with the ability of terminals to fully load ships.

The rail and grain terminals throughput levels have increased but the inventory capacity at the terminals has remained little changed. The consequence is heightened importance of the timely arrival of specific rail cars to meet the loading requirements. Unfortunately, the system, with rail at its centre, is not able to achieve the desired delivery performance with the consequent disruptions to ship loading. Processes and contracts are needed that enable rapid identification of problems, sharing of information about them and cooperative adaptations to the unexpected conditions (Williamson 2002). These are relationships that are difficult to achieve, especially when multiple organisations are involved and when there has been a long history of adversarial relationships.

The direction of the effects of forecasting, contracting, asset ownership, SKUs and the effects of rail service levels are predictable but not readily measurable. However, the effect of rain on the loading of grain in Vancouver is a common complaint and more quantifiable.

Rain days

Ship captains are responsible for the safe loading of their cargoes which includes ensuring that grain is not wet as this can lead to spoilage. Consequently, if adequate protection cannot be given when it is raining, loading may be stopped. Although tarping and loading through a feeder hole is possible in rain, its practice is limited because a union agreement requires railings to be placed around a hold for safety reasons, a process that takes 3–4 h and four additional crew members for mobilization and de-mobilization (Quorum Corp, 2020a). As a consequence, grain is generally not loaded in rain; labour shifts may not be called out if persistent rain is expected. The effect of rain days on port productivity is a very public matter (White 2022; Edmiston 2022b).

While the cessation of loading for rain is an obvious constraint on terminal activity, the magnitude of the effect on the loading of ships and their ultimate departure from Vancouver is uncertain. A regression of the time at berth versus rain days with more than 5 mm of rain for the VFPA data resulted in a regression coefficient of 0.1008. A comparable exercise by Quorum for the five main terminals in Vancouver and using a rain day as more than 8 mm produce a regression coefficient of 0.0475 (Quorum 2020). It is evident that individual rain days are not major determinants of loading variability; some 90 to 95% of variability is the result of the other factors.

A measure of the effect of rain days on anchorage levels is to examine the actual rate of completions of ship loading during wet periods. Applying a rain day as 8 mm plus to the VFPA data, the average number of ship departures from the port for different weather conditions drops from the annual average of 2.22 per day for dry days (this includes the summer months when terminal maintenance is performed) to 1.38 per day for two consecutive wet days and to 1.00 per day for five consecutive rain days (that occurred twice in the four years). There is an obvious build up of ships at anchor when it rains.

General inferences from the conditions affecting variability

The nature of the factors related to the variability of loading times in the port of Vancouver, raises strategies of general applicability to supply chain performance. Some are primarily individual corporate initiatives, others require or are likely to involve wider participation.

The first strategy is for a large producer to extend control along the logistics chain. This is most likely to be beneficial when a part of the logistics chain involves shared resources. In the case of the use of Canadian mainline rail service, this can only be achieved by railcar ownership and maintenance. In the case of port terminals, exclusive use may be possible, as is dominantly the case for potash and grain, while coal is shifting to greater reliance on an own terminal strategy. Potash is the only one of the bulk products studied that has adopted a dominant C&F strategy giving it control of most marine operations. This reflects various conditions of the overseas markets (Heaver et al. 1981).

A second strategy which may or may not be under corporate control is the product mix, the number of SKUs. In Canada, the Canadian Grain Commission regulates grain handling and establishes and maintains science-based standards of quality for grains. The buying strategy of grain companies and their port inventory strategy in the face of the large number of SKUs is unknown. However, the possibility of some consolidation of particular SKUs in particular terminals might be considered, especially as some terminals are co-owned (Heaver 2019). The strategy would be comparable to Canpotex reducing the inventory burden of multiple grades by allocating grades between its terminals in Vancouver and Portland, Oregon.

Collaborative relationships among members of supply chains are fundamental to dealing effectively with inevitable disruptions to demand and supply conditions at different points along supply chains. The perspective of Williamson (2002) on the need for relationships that enable cooperative adaptions to challenges is not just academic. The National Supply Chain Task Force (2022) identifies greater collaboration as having a central role in improving supply chain performance. A response of the Minister of Transport is to require the railways to release more information on their operations with the intention of "…building even more productive exchanges among supply chain members" (Transport Canada 2023). However, whether requiring one party in the logistics chain to divulge more information leads to more collaboration remains to be seen (Trains 2023). Achieving such relationships requires leadership, the use of excellent technologies and having labour force flexibility.

The need for strategies to deal with specific labour availability and skills level is no surprise; nor would be strategies to deal with specific investment requirements. The existing labour agreement governing conditions under which grain is loaded in rain is a specific example where the details of a labour agreement affect the reliability of a supply chain. But, as has been noted, the effect of rain days on the variability of loading rates leaves some 90–95% of that variability due to other causes. Also, decisions on whether to load when it is raining is affected by the incidence of the costs of delaying ship loading.

The incidence of anchorage costs

The incidence of the environmental and economic costs of anchorage are important to the formation of public attitudes, to the need for ships to anchor and to the development of related logistics strategies. The incidence in the broad framework set by international law.

The international regime

Anchorage in territorial seas is embodied in the freedom of navigation as set down in the United Nations Convention on the Law of the Sea (UNCLOS 2022). Countries that are not signatories, such as the US, generally follow its provisions, (Ankersen et al 2012). Article 21 recognises that states may adopt laws and regulations related to the activities of ships in the interest of the safety of navigation, the protection of the environment and the prevention of pollution. However, subject to such constraints, ships have the right of free passage, including anchorage (Clear Seas 2022).

National governments regulate international shipping but the administration of anchorages may be delegated to regional or local governments or to port authorities. They make decisions on the location of safe and environmentally satisfactory anchorages within their jurisdiction, as is the case of VFPA in its waters while TC designates anchorages elsewhere.

The environmental costs

The environmental costs of ships at anchor are diverse and vary with conditions at anchorage locations. They include harm to the sea floor, extended time of air pollution and risks of spills, risks associated with dragging an anchor (TSB 2020), and the effects of noise and lights on near-by residential areas. While some exporters and shipping companies may adjust their behaviour in response to the environmental costs, the reality is that the environmental consequences of anchoring incidental to trading in Vancouver currently do not have a material effect on ship operations. Whether the code of conduct proposed for Vancouver is an acceptable instrument remains to be seen.

The economic costs

To affect corporate behaviour, the economic costs of anchorage need to be reflected in financial costs faced by businesses. The costs that relate to navigational safety and the provision of anchorages cannot be charged for directly. The costs include studies to assess the environmental aspects of anchorages and the costs of monitoring and responding to ship activities. These costs are subsumed under port dues or similar charges.[9] They have no effect on anchorage decisions as they are charged to ships, scaled by ship size, in Vancouver, for each commercial call for the first five calls a year. However, the level of charges, if based on cost, would not have a material effect on the level of anchorage. If regulations, consistent with the United Nations Conference of the Law of the Sea, were in place, it would be possible to take legal action against a ship suspected of violating a regulation. The cost–benefit of regulation would depend on the cost-effectiveness of monitoring and enforcing regulations and of the alternatives, such as a code-of-conduct program.

The costs that have most relevance for shipping decisions are those accruing directly to ships. They can be placed in four categories for ships arriving in ballast.[10] They are: the uncertain availability of the ship for subsequent deployment; hull fouling from extended anchorage with consequences for ship speed and fuel consumption; additional

[9] In some ports, for example, Genoa, the term 'anchorage' appears in the port tariff, but it is actually equivalent to 'port dues'.

[10] A fifth cost, the inventory cost of cargo on board, would be relevant for ships waiting to discharge cargo.

costs while in port; and the opportunity cost of ship time. The latter is the most significant. The incidence of these costs and their actual or potential significance depends on the circumstances of a trade.

The incidence of ship costs

In the case where the shipper owns or controls the ship on a long-term charter, he is faced with all the ship costs. In this case, the shipper's interest is in the most efficient use of ship time in light of terminal and inland logistics costs. The responsibility for all costs warrants a lower optimal sailing speed for the ship at sea when it is known that the ship will have to wait at anchor. This does not mean that ships will not anchor but that it will be avoided as far as is practical. This condition contributes to the low level of anchorage in the fertiliser trade, thanks largely to the logistics strategy of Canpotex. In cases of ships on a voyage charter, the terms related to arrival and loading time are important.

First, the need for a laycan period to cater to the uncertain timing of ship arrival imposes inventory and associated logistics costs on shippers. For example, decisions to order railcars for specific contracts may well be required prior to knowing when a ship will issue its NOR within the laycan period. Also, the bunching of arrivals of ships for different cargoes complicates rail order planning and maintenance of inventory levels. Ship captains or agents are usually required to give 15 and 7 days notice of the expected NOR date and tracking systems now allow a ship's location to be pinpointed. Nevertheless, the complications of managing terminal inventories to match inbound ship movements give rise to the need for anchorage.

Second, typical terms of voyage charter parties encourage ships to sail at speeds optimised for early arrival within the laycan period regardless of whether they can proceed to a berth or have to anchor. The race to wait is accounted for by the commencement of the free time allowed for loading (or unloading) on the issuance of the NOR under the charterparty terms. The earlier NOR is issued, the sooner demurrage payments become due.[11] Although a virtual arrival clause has been and still is widely advocated to avoid the race to wait, it is not used in Vancouver and is little used globally (Heaver 2021, 2022a). In Vancouver, the reasons appear to be threefold: Charter contracts in FOB sales have to be negotiated by the buyers although the operational responsibilities would be between the ship and the exporter; the magnitude of the financial benefit may not warrant the effort; and the potential environmental costs do not enter into the equation. However, this should not be true in the future as costs of greenhouse gas emissions associated with the way in which ships are operated are now becoming relevant to ship owners and traders through IMO initiatives, such as the Carbon Intensity Indicator, (Andersen 2023) and the European Union's implementation of an emission trading system for shipping (Dimitry 2024).

There have been occasions in which localised public interventions have led to placing ships in a queue before they arrive. Such was practised in Southern California in the liner trades in 2022 and has been long practised under the Ship Arrival System in Newcastle, Australia (Heaver 2022b, 2020) In each of these cases, institutional intervention was required but the virtual arrival clause does not require it.

[11] Demurrage is the payment to a ship held for loading beyond the free time. It is paid by the exporter: under the charterparty in the case of a C&F sale; the exporter pays under the sales contract in an FOB sale.

Third, charterparty terms determine which days after NOR has been delivered are in the free loading time, laytime, when a ship's costs are to its account. In the Vancouver grain trade Saturdays, Sundays and holidays are excluded (SSHEX).[12] In the coal trade, they are included (SSHINC). For rain sensitive cargoes such as grain, a weather permitting clause may exclude rain delays from laytime for ships being loaded and for those that have provided NOR and are waiting to come to that berth.

The SSHEX and rain day terms mean that terminal decisions to load on a Saturday, Sunday or holiday or to avoid loading in the rain impose time costs on ships. The environmental costs of ships at anchor are also likely ignored. The consequences are a greater incidence of anchorage waiting time than is economically warranted and freight rates that reflect ship owners' expectations of delay costs.[13]

There is no evidence that the higher freight rates are incorporated in grain company loading decisions as the negotiation of charterparties and management of terminals are geographically and conceptually separate. Also, there are limited corporate relationships between ship owners and grain exporters that would enable negotiated rates reflecting the probability of anchorage time.[14]

Removing exclusions from laytime (SSHEX days at anchor and rain days) would shift the time cost of the shipowner into a demurrage charge.[15] The amount reflects the time value of the ship, typically the expected time charter rate estimated at the time of chartering, fuel consumption at anchor and other operating costs, in US dollars. In mid 2020, the demurrage rate for a 70,000-deadweight tonne bulk carrier might have been about USD 11,000 per day.

Increasing demurrage costs would be controversial with farmers who, as price takers in international markets, are very much aware of these costs. The average cost of demurrage per year over the 10 years to 2020 was $25.7 million.[16] In 2020, this was equivalent to a cost in excess of one dollar per tonne across the grains exported through BC ports and is equivalent to about one per cent of the estimated total cost of moving grain from a central location in the prairies to ship loading in Vancouver, based on values in Boersch and Temple (2020). However, this is only the visible cost of delays. The delay costs that currently fall on the ships get built into the freight rates. Assuming 450 grain ships per year incur an average of 4 SSHEX and rain days delay, and daily demurrage value of USD 11,000, this cost is USD 19.8 million. Quantifying and giving visibility of actual costs would increase the pressure to improve the management of the issues behind the efficient loading of ships.

[12] For grain, NOR can be only given 09:00 to 17:00 Monday to Friday with laytime commencing the following 08:00. This means that laytime commences at 08;00 Tuesday for a ship able to provide NOR (after arrival and inspection) only at 18:00 h on Friday.

[13] The opportunity costs of idle terminals commonly result in shifts being worked on SSHEX days. The implication of this for laytime calculation of the ship worked depends on whether laytime includes or excludes 'used' time. It does not affect the laytime of waiting ships.

[14] A model for such an approach is developed by Sun et al. 2021.

[15] Working on a rain day would reduce the exposure to demurrage but only to the extent of .75 demurrage time as loading under protection is less productive than free shoot loading.

[16] Calculated from the Quorum Corporation, Grain Monitor, Report Annual, data tables, Table 5D-4. The data are for the Canadian 'Pacific Seaboard'. Vancouver accounts for 15–20% of grain tonnage.

Summary of the challenges and opportunities to reducing anchorage

The crux of the challenge to reduce anchorage is to have inventories of commodities matching the contracted demand of ships when the flow of freight and arrival of ships are both uncertain. The simulation model based on attributes of the port of Vancouver has identified the variable loading time of ships as the critical condition linked to the waiting time of ships. This end result reflects the challenges in the individual commodity supply chains as well as the logistical interactions among them. However, the resulting amount of ship waiting time is also affected by specific conditions in maritime contracting.

Supply chain conditions

The challenges have differences and similarities across the grain, coal and fertiliser industries. Some of the challenges are essentially inherent to them, for example, the unpredictability of grain harvests and geographically spread origins. The need for grain and potash to be protected from rain has particular implications for the loading of grain to ships in Vancouver. Other challenges are partly inherent and partly exist through choice. Such is the case with the number of SKUs for grain; higher logistics costs are accepted to achieve heightened market demand and price. The choice of railcar ownership is another example.

There are important differences in the extent to which the companies own or control logistics assets. The notable contrast is between the fertiliser trade where the strategy of Canpotex is worthy of global recognition, to the grain industry which only recently has been increasing its ownership of railcars.

The ownership and therefore greater control of railcars reduces but does not eliminate issues surrounding the quality of rail service in a system that faces periodic congestion challenges. For companies across the sectors, a dominant matter is the quality of the relationships between the shippers and the railways. In any walk of life, relationships can usually be improved but achieving more collaborative relationships between the railways and shippers, particularly the grain shippers, is central to getting better logistical results, including anchorage outcomes.

Maritime conditions

Achieving better logistical outcomes in terms of reduced anchorage also faces challenges in maritime matters. The most specific is to enable loading in rain. The more general is to consider charterparty terms that result in the incidence of ship costs falling on those with responsibility for them. It appears that the potential increase in demurrage would be significant. How much change would result from this is unknown but the expected result would be more visible but less cost overall.

Initiatives to slow the arrival of ships could make logical but not large reductions in ship waiting time. They are initiatives to slow the arrival of ships that might arrive prior to their laycan and the use of a virtual arrival clause in charter parties. Management of the environmental costs of ships at anchor might be considered by regulating shipping activities if a code of conduct is not effective.

Achieving change in logistics arrangements whether between the railways and shippers, between different interests in the port community, between SGI residents and the maritime sector, and between farmers and the logistics suppliers on whom they depend, all depend on collaboration based on shared information and shared goals to improve productivity.

Vancouver is an unusual microcosm in which to deal with the challenge of ships at anchor; dependence on long-haul rail services, diverse and expanding trades, and the available anchorages for increased traffic being limited and in highly sensitive locations. Without changes, the need for anchorages will likely increase as asset utilisation increases along with increased trade volumes. There is no quick fix but there are many avenues to pursue to reduce the need for ships to wait, which would be to everyone's benefit.

Questions for further research

Four questions arise for subsequent research. The first question is whether or not the time costs that befall grain ships in Vancouver are reflected in voyage charter rates? This is a pragmatic question of academic and practical interest. It gives rise to two approaches. The first is to explore actual rate setting practices which would enable testing the framework outlined by Sun et al. (2021). The second would be to compare the charterparty terms and rates, on a time charter equivalent basis, of similar commodity trades with a different incidence of anchorage.

The second question is how does actual practice compare with optimal strategy when firms commit to export sales volumes when faced with uncertain delivery capability? Is heightened variability in deliverable capability associated with reduced sales levels? What differences might be expected and exist between commodity trades and for a commodity during different seasonal shipping conditions?

Third, what are the impediments to the use of practices to reduce ships' race to wait? The obstacles have not been documented adequately. Documentation would be of benefit globally.

Finally, research will be needed to investigate the costs to shipping and the response in trade logistics to the greenhouse gas measures of the IMO and the emissions trading system of the European Union.

Abbreviations

AVTM	Advanced Vessel Traffic Management initiative
C&F	Cost and Freight
FOB	Free on Board
IH	Inner harbour
IMO	International Maritime Organisation
LOA	Overall ship length
NOR	Notice of Readiness
OH	Outer harbour
PPA	Pacific Pilotage Authority
SGI	Southern Gulf Islands
SKU	Stock keeping unit
SSHEX	Saturdays, Sundays and holidays are excluded
SSHINC	Saturdays, Sundays and holidays included
TC	Transport Canada
VFPA	Vancouver Fraser Port Authority

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Declarations

Competing interests
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