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Dynamic Changes in the Structure and Concentration of the International Grain Trading Industry

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Abstract The international grain trading industry has a long history with varying documentations commencing from the 1970s. These references address he Russian grain deal, into the 1980s, to more recent books and reports, to now including Russian grain trading and optionality as a strategy for commodity trading firms. While many of these studies sought to explain the mystique surrounding the international grain trading industry, many are descriptive and/or refer to other studies. It is frequently claimed that the international grain trading industry is highly concentrated and controls 80% or more of world trade. Limited data is provided to support this claim or to suggest any geographical, temporal, or sectoral differences. None of these publications refer to the emerging competitive fringe firms, including but not limited to CHS, Glencore, Viterra, Olam, Wilmar, COFCO, Gavilon (now 100% part of VIterra), Soufflet (Invivo), Nibulon, etc., as well as the emerging Russian grain trading firms.

The purpose of this paper is to document the evolution of firm and industry strategies and to analyze detailed data on the structure of the international grain trading industry. Specifically, data is developed from vessel nominations to 1) analyze measures of concentration, 2) determine how these change across selected geographies and commodities, and 3) determine the composition of a cluster of firms in this industry. The results provide fresh documentation on the structure and concentration in the world grain trading industry. The results indicate the levels of concentration are much less than traditionally suggested, there has been growth by many new entrants making up a viable competitive fringe, the industry seems to be comprised of three clusters of firms, and generally, competition in this industry would be characterized as being “fierce.”

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Introduction

The international grain trading industry has undergone significant and rapid changes over the past five decades, leading to a lack of comprehensive understanding of its current structure. Historically, the industry was dominated by private firms and heavily influenced by government interventions. However, it has transitioned with an increased number of firms and evolving government impacts. During the 1980's the Export Enhancement Program (EEP) severed the traditional relationship between buyers and sellers. Recent years have witnessed notable shifts in the industry's landscape, the emergence of a viable competitive fringe, including the rise of trading firms in China and Russia, and extensive geopolitical interventions resulting in embargoes and trade-related taxes. These factors have led to increased volatility in futures, basis and shipping cost, all of which resulted in more volatile margins and distorted trade flows.

Despite these major changes in policies, there has been a dearth of in-depth analysis regarding the industry's structure. Measures of concentration have evolved, yet they often overlook the influence of new market entrants, a substantial and viable competitive fringe and the role and impact of Russian and Chinese trading firms.

The purpose of this study is to analyze comprehensive data about the structure of the international grain trading industry and document the evolutionary patterns of firm and industry strategies. Specifically, we utilize data on vessel nominations to 1) analyze concentration measures, 2) assess how these measures vary across different geographical locations and commodities, and 3) determine the composition of clusters of firms within the industry. The results of this study offer fresh insights into the structure and concentration of the global grain trading industry, presenting a departure from existing literature and providing a more comprehensive depiction of the industry's organizational framework.

Background and Previous Studies

External Influences Affecting the International Grain Trade: Firms in the international grain trading industry have been impacted by numerous evolving institutional, policy, and geopolitical changes. During the 1970s, there were large surpluses, relatively stagnant markets, and government efforts to control export pricing. This sector was also dominated by government buying and selling agencies. The Russian grain deal occurred during that period resulting in concerns over industry concentration, transparency in prices and exports, export sales reporting, etc.

[1] A version of this report is available at Wilson, Bullock and Dubovoy (forthcoming). A summary of this report is available at Wilson, Bullock and Dubovoy, 2025a and 2025b.

There were growing surpluses in the 1980s. During that period, export subsidies emerged to enhance sales when domestic prices exceeded international prices. Export subsidies were used in the European Union (EU), and the United States adopted the EEP program. Concurrently, State Trading Enterprises (STEs), in part, justified their importance to strategically combat these interventions. Of importance to the international grain trading industry is that these mechanisms severed the relationship between international sellers and their customers as the governments became more involved in determining transaction prices and sales between specific trading firms and buyers.

Following this period, concerns developed about the growing power and adverse implications of STEs. The World Trade Organization (WTO negotiations of the 1990s encouraged STEs to have a reduced role (i.e., suggested "voluntary elimination" of many STEs) in world commerce, and this resulted in the beginning of the demise of many of the world's STEs that were important in grain (e.g., Canadian Wheat Board (CWB), Australian Wheat Board (AWB), CONASUPO and many others), and most were dismantled, but not all. These changes resulted in a greater decentralization of grain trading and privatization of grain marketing import and export functions and had significant strategic implications for international grain trading firms.

The biofuels industry escalated in importance in the United States and other countries in the mid-2000s. This had several substantial impacts. One is that a more significant share of supplies was used domestically to produce ethanol, renewable diesel, and, prospectively, Sustainable Aviation Fuel (SAF). The emergence of these new processing industries also provided investment opportunities for many firms, including grain trading firms.

Following the escalation in commodity price risk in 2008, most trading firms adopted varying forms of the Value at Risk methodology (VaR) to manage trading risks. During the early 2020s, numerous concurrent factors caused an escalation in risk and grain price volatility. These include reduced stocks, increased geopolitical interventions, climate pressures, and supply chain problems. Cumulatively, these caused an escalation in risk in not only futures values but also basis (Bullock et al., 2023) and other marketing functions (shipping costs, margins, etc.). The impact of the changes in volatility resulted in increased revenues for commodity trading firms. Franke et al. (2023) described margins of commodity trading firms, inclusive of "agricultural and food products," and indicated four factors supporting trading profits, including 1) dramatic increase in volatility, 2) tight stocks, 3) changes in trade flows and 4) the demand for cash to meet futures trading margin requirements (margins for trading firms tripled in 2022 vs 2021). Though this was discussed across all commodities, the results were similarly important (though maybe less dramatic) for agricultural trading firms. They suggested the larger firms were positioned strategically to exploit their multi-origin supply arbitrage. The increased profits by commodity trading firms were also described by Rechtsteiner et al. (2023) and illustrated that returns were correlated with volatility

(using the volatility of soybean oil) and that firms with embedded flexibility (optionality) were positioned to thrive.

By 2023 and 2024, there were two significant changes. One is that volatility had appeared to subside, which resulted in reduced trading profits. Wilson (2024) indicated Trafigura's profits decreased by 70% and was in response to the reduced volatility in 2023 ("a sign of an end of the extreme market volatility that has boosted the earnings"). Second, by early 2024, the agricultural market for commodity trading became more subjected to geopolitical pressures, waning supplies, climate pressures, etc. In response, there was an escalation in various interventions (Reidy, 2024; Speed & Savage, 2024), including non-tariff trade barriers, stock-holding, embargoes, and export controls. They indicated that 'non-tariff trade barriers in 2022, in response to the war, increased to 1,266 from 154 countries," resulting in an "exaggerated demand-supply imbalance." Olam's Chief Executive indicated the "world is headed for 'food wars' as geopolitical tensions were pushing countries into conflicts." These developments have essential opportunities and implications for international grain trading firms.

New Entrants and Growth of Competitive Fringe: The origins of the international grain trade were traced to Ancient Greece and Rome including the inception of many important features of the modern trade (Atkin, 1992). The early major firms in the modern international grain trading industry were Andre, Bunge, Cargill, Continental, Dreyfus, and Cook. Each was a large private family-controlled corporation. Over time, some of these exited, others were acquired or became insolvent, and the remaining ABCDs (ADM, Bunge, Cargill, Dreyfus) came to be more subject to either public ownership or financial disclosure in varying means (e.g., as public stock-held firms, ESOPs, etc.). In addition to this structural change, numerous firms entered the international grain trading industry. These new entrants and others ultimately form the competitive fringe of firms in international grain trading.

Without being exhaustive, the new entrants can be classified into several categories, including state trading enterprises (STEs) such as the AWB and CWB; cooperatives like Farmland, CHS, and Central States; and most Canadian prairie cooperatives forming Viterra. Japanese trading companies including Marubeni, Mitsubishi, Itochu, who jointly owns Consolidated Grain and Barge (CGB) with Zen-Noh (a Japanese cooperative. These are in addition to Korean trading firms Posco, Daewoo and CJ International Asia. Other noteworthy entrants are the *Asian Tigers* or *Merchants of the Orient* (Wang & Li, 2010), including Noble, Olam, and Wilmar. In 2025, the remaining shares of Olam Agri were acquired by SALIC (Okoh On, 2025).

Private commodity trading companies include Phibro, Ferruzzi, Gavilon, Agrex (Mitsubishi), Glencore, J. Aron, BGT, ETG, Serentz, Atlas, Greenfield, Hartree Partners (ex-Goldman / HessGunvar), and Vitol. Others entered including Grain Corp (Australia), Lansing Grain (now Andersons), Quadra (AWB traders in Geneva), and Invivo, who now owns Soufflet, and Copenhagen Merchants. Following the Russian invasion of Ukraine and the subsequent exit of some major players from Ukraine trading, several new

Ukrainian firms expanded into trading. Subsequently, most of these firms exited. Concurrently, there was an increase in the number of Russian grain trading firms.

Finally, several firms expanded into trading which sought to digitally integrate commodity supply chains and high-tech platforms. These include Indigo, Farmer's Edge, FBN, GroIntelligence (Time Magazine's 100 Most Influential Companies). These firms thought to be well-capitalized with high-tech trading platforms, sought to disrupt the grain trading sector. Ultimately, these firms failed, and they exited the sector (Chipman & Hirtzer, 2024).

These *de novo* and, in many cases, greenfield expansions into international grain trading indicate that entry is not prohibitive. Some were successful (e.g., Gavilon, Viterra, Glencore, and others), but many were not and either exited or were acquired. In most cases, these firms realized that trading and managing logistics of international grain trades are more complicated than envisioned (i.e., as in trading futures), the importance of counterparty risk, and multi-origin optionality.

There are two significant additions to the above, and these relate to the entry and/or expansion of trading for Chinese imports and Russian exports. Each is discussed below.

Chinese Trading: China emerged as a large and growing market for international agricultural commodities commencing in about 2000. Initially, China became the dominant soybean importer, and more recently, it became a dominant importer of corn, wheat, and beef cattle. As a result of this growth, China sought to diversify its suppliers and sources and "wanted less dependence on ABCD" (Roberts, 2014). Ultimately, it was said that "The Chinese Want Their Own Cargill" (Roberts, 2014), and more recent policies pursued diversification (National Development and Reform Commission, 2023). COFCO International[2] grew to assume the responsibility for managing a portion of China's imports. They initially acquired Nidera, Noble Agri Ltd., and subsequently others.

COFCO International was formed in 2014 and is a subsidiary of COFCO, a state-owned enterprise (COFCO International). In 2024, they had operations in 37 countries. COFCO has heavily invested in supply chain functions, including origination, storage, ports, and shipping, and has logistical capacities in South America,[3] Eastern Europe, and the United States. COFCO International continues to grow and, in mid-2024, swapped assets to gain access to the US Gulf ports and indicated their intent to expand at these ports (Clayton, 2024). They ship to China and are significant shippers to many other countries. They are a large shipper of grains from the United States and other countries. It has grown in revenues and was planning an IPO (since 2021). COFCO

[2] In addition to COFCO International, there are other emerging and, in some cases, large Chinese trading firms in grain, including Wilmar, XMXYG, Pengdu Agriculture, Beidahuang Group and Shenzhen Cereals Holdings Group. SinoGrain was relegated a role for storage in 2022 (Chang, 2022).

[3] See Cang, Gu and Sousa (2024) about COFCO's expansion in Brazil.

International agribusinesses now have revenues second to Cargill in 2022, exceeding that of ADM, Viterra, Wilmar, Bunge, and other major agribusiness firms.[4] Taken together, COFCO International has many characteristics of an STE.[5]

Russian Grain Trading: The Russian grain trading industry has evolved radically and is essential in world trade. Traditionally (pre-1990s), Russia's grain trade was controlled by Exportkhleb (Crawford, 2022). Under Perestroika, the industry was largely decentralized (Wilson & Belozertsev, 1995), and various forms of commodity markets have evolved. Major international grain trading firms expanded into varying functions within the interior and offshore markets but by no means dominated the industry.

Russian trading firms also evolved. VTB (https://www.vtb.ru) sought help from the Kremlin to create a Russian grain champion to curb the role of foreign traders (Houghton, 2019). Russia became concerned about food security when Western sanctions were imposed in 2014. In 2019, the VTB consolidated its role in local grain marketing and expanded it into trading, logistics, and port handling. VTB's grain holding company, Demetra, intended to control the supply chain and become a multinational giant; the company was partly owned by private firms and partially state-owned through VTB. Concurrently, United Grain Co. (https://ozk-group.ru) became a commercial company, was primarily state-owned, and sought to control the supply chain (it owns facilities, rail cars, etc.), becoming a dominant exporter from the Black Sea. Taken together, Russia evolved with two competing firms: state-owned and quasi-state-owned.

Following the Russian invasion of Ukraine, the Kremlin designated importing countries as "friendly" or "unfriendly," which became part of the export strategy. In late 2022, the Kremlin issued a decree prohibiting companies from "persons related to unfriendly states" from buying grain from Russian farmers. This action reduced trading opportunities for non-Russian firms and increased profits for Russian-trading firms. In early 2023, these developments, among others, effectively forced Western agricultural trading firms (including Cargill, LDC, and Viterra, as well as an earlier autonomous exit by Bunge) to liquidate their assets and exit Russia's grain-trade sector (Popva & Plume, 2023; Sonne et al., 2023; Terazono, 2023).

By mid-2023, the Russian Ministry of Agriculture was intimately involved in grain export pricing and contracting.[6] The ministry aimed to reduce interior Russian prices to forestall inflation and earn a duty on exports. The Ministry "informally fixed" minimum export prices.[7] Exporters had to register trade above the floor price and report their minimum purchase price at the ports. Any exporter that registered lower prices was

[4] ETC Group's Food Barons report of 2022 (Shand et al, 2022) put COFCO as the second largest company of the 'Leading Agricultural Commodity Traders'. https://www.etcgroup.org/files/files/food-barons-2022-full_sectors-final_16_sept.pdf

[5] Technically, COFCO International is a subsidiary of COFCO which is a STE.

[6] Traders reported that the Ministry of Agriculture began executing a two-price system: one for private transactions and one for tenders (El Safety and Hogan, 2023).

[7] This practice has come to be known as the "AgMin" floor (Reuters, 2023a) or is referred to as the "unofficial price set by the Russian agriculture ministry."

punished commercially (e.g., had difficulties with phyto-certificates without which the crop could not clear customs). Indeed, Vorotnikov (2024) suggested the Ministry of Agriculture forced consolidation of the Russia grain industry in order to enhance its ability to control its functions.

The structure of the exporting grain industry in Russia has evolved radically (Belikova, 2024; Glauber, 2023; IFPRI 2023; Quinn, 2024a and 2024b). Early on, Grain Gates was the dominant export firm, followed by TD RIF (Grain Flower, previously named GTCS) and Aston. Quinn (2024a) indicated that the top five exporters shipped 58% of the exports. The only multinationals reported were Dreyfus and COFCO. In the 2023/24 crop year report, Quinn (2024a) reported that the Russian grain trading firms increased their market share. By 2023/24, most of the Western trading firms had exited. Grain Gates, TD RIF, and Aston were the dominant exporting firms. TD RIF has since exited (AgriCensus, 2024; Quinn 2024b), and Grain Gates is formally a private company but associated with Demetra, which, as a private company, is associated with VTB.[8]

Taken together, the critical points for purpose of this study is that 1) Russia is a significant exporter, particularly of wheat; 2) following privatization, many western trading firms were active in Russia grain exports; 3) due in part to sanctions in 2014, there were efforts to grow domestic Russian grain trading firms; and 4) following the Ukraine invasion, western firms were primarily forced to exit, replaced by a cabal of Russian trading firms which are now consolidating to a few dominant exporters.

Strategies and Economies of International Grain Trading: The strategic scope of firms in international grain trading changed radically after the 1970s. Before the 1980s, the trading environment was generally characterized as a few largely private firms; most information (e.g., prices (basis), export sales, and shipments) was not public; exporting firms mostly were not vertically integrated. Farmers (at least in the United States) had limited storage and information and therefore had to sell, and logistics was a regulated function, etc. Since then, all of these have changed and affected the economies of trading firms and their apparent strategies.

Caves (1977/78) provided an early strategic interpretation of the international grain trading industry, and Morgan (1979) provided a more popular interpretation. A few firms controlled the international grain market, commonly known as ABCD. This structure was partly due to two sources of economies of scale. One was economies of scale with facilities (storage and handling) and shipping costs (Caves 1977-78), and the second was economies of scale for information, which were intangible and asymmetric. Indeed, an essential function of strategic advantage was information, and firms sought to build their information sources. These functions have high fixed and low marginal costs, and deterred entry. Given these advantages, incumbent firms could control trade flows and exploit logistical bottlenecks, resulting in transitory arbitrage opportunities.

[8] There were additional changes in 2024 which are described in Belikova (2024).

Indeed, Caves (1977/78, p. 120) suggested that concentration increased in the grain trading industry due to the long distance and onerous information requirements.

Changes began to emerge in the 1990s, highlighting the importance of optionality (Meersman et al., 2012) in international trading. Information became more transparent, and large multi-origin incumbent firms began to lose the source of their asymmetric advantage. Optionality refers to the ability to shift origins and terms of trade, thereby inducing multiple origination capabilities in response to volatility and/or Black Swan events. Commodity-trading firms are considered "masters of optionality." They have complex networks of assets, guaranteed supply contracts, and long-term supplier agreements. In the case of grain trading, this motivated multi-origin capabilities. The value of real options for international grain trading was quantified (Johansen & Wilson, 2018) and supported by recent developments [as explained by Blas & Farchy (2021) and Kingsman (2021)]. The advantages of multi-origin shipping have been embraced with the escalation in optional origin contacts, contracts with switching provisions and washouts, not dissimilar from switching options in ocean shipping (Sødal et al., 2008) and sugar and ethanol processing (Bastian-Pinto et al., 2007).[9]

With near-ubiquitous information owing to digital technology (Belt & Boudier, 2020; Belt & Porsborg-Smith, 2020; Donnely, 2022; Reidy, 2021; Reinsel et al., 2018), the traditional source of asymmetrical information advantage was lost. This situation resulted in a shift of functions from "having" information to "data analytics." Indeed, a major grain trading firm "…invested significantly in tools, such as artificial intelligence and machine learning. It hired data scientists, using information gathered from public sources and its assets…," which, taken together, would provide an "edge" during major events (Vanian, 2018).

In the early 1990s, grain firms' strategies evolved toward greater vertical integration. This was a significant change and required substantial capital investment in fixed assets. Vertical integration of grain trading firms was primarily driven by the demand for greater logistical control (given the concurrent deregulation in transportation), quality control, and a strategy to mitigate firms' market power elsewhere in the vertical market system. The costs of implementing these strategies were one reason for the merger of Continental Grain with Cargill (Hayenga & Wisner, 1999).

Vertical integration also expanded grain trading firms into value-added activities. In part, expansion into value-added varied across industries due to the strategic issue of competing with customers. Nevertheless, grain trading firms expanded extensively into flour milling, malting, oilseed crushing, biofuels, and varying sectors in livestock. More recently, most grain trading firms are extending their functions to manage and trade sustainability and carbon initiatives.

Commencing in the 1990's rail shipping had two significant changes. One was the change from single-car shipping to multi-car shipping, which increased scale. The second was developing a tradable market for rail cars in the United States and

[9] Hauck (2024) provides a statistical summary and categorization of these types of contracts in international grain trading.

subsequently adopted in other countries (Wilson & Lakkakula, 2021). These changes resulted in greater scale in shipping and risks not confronted previously and induced a greater integration of grain trading and logistics management, ultimately having more control over the functions in the supply chain. Indeed, Wilson and Klebbe (2024) suggested an essential shift in the United States grain marketing: under the current logistics regime, grain traders "strategically make decisions on rail car acquisition and then acquire grain to meet their expected placement and timing of rail cars."

Increasingly, the apparent strategy of most grain trading firms involves supply chain management. In contrast to the early years when exporters largely bought grain delivered to the port, this has changed radically. Now most grain firms have supply chain management as an integral function (Bertelsen, 2018; Ching & Lau, 2012). The overall goal is to coordinate the functions from origination to handling, interior shipping, export handling, storage, and, in many cases, international shipping and distribution. The challenge is that each function is subject to risks and mitigation strategies, and coordination is crucial.

Finally, throughout this evolution, a stalwart function with international trading is the prominence of tenders, an essential form of "price discovery" affecting the structure and conduct in this industry (Wilson & Dahl, 2005b; Wilson & Diersen, 2001; Wilson, Shakya and Dubovoy, 2025). Some tenders are private (i.e., private auctions where the results are not disseminated), which increased following the privatization of many public import agencies. Auctions are prominent in part because, traditionally, buying and selling organizations were dominated by governments. With the privatization of importing functions in many countries, numerous buyers continue to use auctions, albeit with less formality and, in some cases, less transparency. Many others are public, and, in some cases, the results are disseminated to the broader market participants. Importers adopt tenders due to uncertainty about exporter costs, a lack of transparency, and the fact that auctions are efficient in determining low-cost suppliers. In recent years, tenders are routinely used in many countries, including Algeria, Bangladesh, Iran, Japan, Jordan, Morocco, Pakistan, South Korea, Taiwan, Thailand, and Tunisia (as reported in Eikon, AgriCensus, and AgriFlow, among others). Tenders pose a challenge to international grain trading firms due to precluding any form of inter-firm price coordination, the need for exporters to be low cost and tenders provide a form of counter-veiling market power.

Evolution of Concentration Measures in International Grain Trading: Concentration in the international grain trading industry has been the subject of numerous studies and books and, more recently, referenced in more popular studies and media. These are summarized in Table 1.

Academic literature has evolved from Caves (1977/78) and Caves and Pugel (1982). Caves (1977/78) indicated a concentration ratio of 80% in international grain

trading, though sources were not identified. Caves (1977, p. 109) indicated the CR4[10] for US domestic grain merchants at 33% and 21% in 1960 and 1972, respectively. Caves (1982)[11] suggested that for 1974/75, an unofficial CR4 of 61%, 42%, and 41% for wheat, corn, and soybean, respectively. CR4's fell for US exports to 1980/81 (citing USGAO, 1982). Using data from NAEGA, the 1974 CR4 for wheat, corn, and soybean was 62%, 43%, and 53%, respectively. Thomson and Dahl (1979) indicated a CR4 of 85%. Their analysis questioned the ability to dynamically coordinate pricing. McCalla and Schmitz (1979) indicated a CR5 of 90% in 1970. Using data from USDA Grain Inspections, Foltz (2002) indicated concentration ratios for US grain exports of 81%, 47%, and 65% for corn, wheat, and soybeans respectively.

Table 1. Summary of Studies Indicating CR4's for International Grain Trading

Author	Year of Publication	Scope	Year of Study	All grains	Corn	Soybean	Wheat
Caves	1977	International		80			
		US domestic	1960	33			
			1972	21			
Caves and PUgel	1982	US exports	1976		42	41	61
Thompson and Dahl	1979		1976	85			
McCalla and Schmitz	1979		1970	90 (CR5)			
Folz	2002	US exports	1999		81	65	47
Crespi and MacDonald	2022	US Exports	1998				47
			2009				65
Other books and Studies							
Frievalds	1976	International		70			
		US exports		90			
Morgan	1979			80-90			
Gilmore	1982	US exports			90		96
Atkin	1992	International		75			
Kingsman	2019	International		50			
Murphy	2012	International		73			

*Morgan's estimates were for the US, EU, Canada, and Argentina and range from 80 to 90. For "Other books and studies," the study date is generally the date of publication or not specified.

[10] CR4 is the four-firm market share and defined as the sum of the market shares of the largest four firms (and defined below).

[11] Citing Wright and Krause (1976) and the USDA.

Several books allude to concentration in international grain trading. Freivalds (1976, p. 116) indicated a CR5 of 90% for the United States and 70% for world grain trading. His results were concurrent with and/or based on investigations by the Federal Trade Commissions in the industry. Morgan (1979) indicated a CR5 by origin country as 85%, 90%, 90%, and 80% for the United States, EU, Canada, and Argentina, respectively, citing a USDA (1975) report. He referred to the 'pyramid of power' and the dominance of the major grain exporting firms (p. 234-235). Gilmore (1982) reported values for US exports of wheat and corn at 96% and 90%, respectively, citing a Senate Committee on Foreign Relations (from Table 3.1, p. 27). Sewell (1992, p. 127) indicated the concentration "…is largely as a result of these risks and pressures that the international grain trade became concentrated into so few hands…." Atkin (1992, p. 112) suggested that the five major grain trading firms account for 75% of grain shipments internationally but acknowledged that 'the exact figure is not known." More recently, Kingsman (2019, p. 222) indicated that ABCD controlled 50% of the world trade in grain and oilseeds.

A number of published studies recently cited varying concentration measures in international grain trading. Several published studies cite varying concentration measures, most originating from Murphy et al. (2012). That study indicated a CR4 of 73%. The basis of that study was an unpublished AWB reference.[12] Upon further investigation, it became clear that the study, which addressed issues of privatizing the Australian grain trading industry, had significant limitations. The study summed the total revenues from public annual reports for Cargill, ADM, ConAgra, Louis Dreyfus, Bunge, CWB, and AWB and derived the share controlled by the largest firms. It was inferred from this data that these firms control 73% of the market share for international grain trading. However, this approach is limited partly because it is based on *a priori* firm composition and of firms having publicly accessible data. Further, using revenues as a proxy for market size in international grain trading would severely underestimate the market size, ignoring actual shipments and the impacts of competitive fringe, etc.

Other studies have referenced the concentration in international grain trading, such as Clapp (2015) and Anderson et al. (2023), citing ETC Group. In addition, Hietland (2024) cited Harvey (2022) and referred to Murphy et al. (2012). Shaxson (2024) referred to that the major players control 70-90% of the commercial grain trading (no reference). They ultimately refer to the AgriFood Atlas (2017, p. 26) that indicates the ABCD group accounts for 70% of the world market for agricultural commodities. DeSchutter (Share the World, 2022) and Public Eye (2019) also discussed this topic. These sources suggest that the concentration in international grain trading ranges from 70% to 90%. Finally, Lionas et al (2024) described concentration in the broader agricultural sectors (e.g., fertilizer, grain, seeds, etc.) and identified a number of potentially adverse consequences of further concentration. In the case of international grain trading, they referred to that "the ABCD companies…hold substantial market shares, which heightens the risks associated with food security" (p. 41), and refer to the 73% CR4 as referenced above. No new evidence about concentration in this industry

[12] Murphy et al (2012) cite the Australian Wheat Board (no date), which we subsequently identified that the source of this information was a non-public report referred as AWB (2004), p. 7 though conducted by Boston Consulting Group (2004).

were provided. More recently, Wionn and Kuepper (2025) suggested the four-firm concentration ratio in cereals, oilseeds and protein crops was 50-60%. These were derived (similar to the Australian Wheat Board, no date, study mentioned above) by aggregating volumes shipped of the top traders, but as in the AWB study ignored the competitive fringe.

These results are important because they have been the subject of numerous stories in the financial trade press seeking to describe concentration in intentional grain trading. These include Pina (2017); Lawrence (2011); Farmer (2017); Putz (2018); Kokkinidis (2023); and Thomas (2023). Each of these either refers to Murphy et al. (2012) or Clapp (2015) or does not provide a source and indicate the concentration in international grain trading is 70-90%. Most of these studies and stories claim that concentration has escalated, which has had adverse consequences. Murphey et al. (2012) indicated, "these four firms are decisive actors in the global restructure of the overlapping food, feed, and fuel complexities." Clapp (2015) indicated that "these firms have enormous power to shape key aspects of the global food landscape." Public Eye suggests a connection to human rights violations. ETC Group suggested these firms "wield enormous influence over markets, agricultural research, and policy development, which undermines food sovereignty."

Heitland (2014) suggested that these firms control the supply side through their large storage capacity, vertical integration, etc., and control the key export and import markets. DeSchutter (Share the Worlds Resources, 2022),[13] said: "The fact that global commodity giants are making record profits at a time when hunger is rising is unjust and is a terrible indictment of our food systems. What is even worse, these companies could have done more to prevent the hunger crisis in the first place." Anderson et al. (2023) suggested that 'big ag' was sufficiently large to influence regulations.

Concentration in Other Agriculture Industries: Concentration has escalated in importance in the United States and the EU across many industries. Issues related to concentration have been less contentious in agricultural industries but have not been without scrutiny.

Recent studies have addressed concentration in other agricultural industries (MacDonald et al., 2023). They pointed to three sectors in agribusiness where concentration has increased over time, including seeds, meatpacking, and food retailing. They reported both CR4 and the HHI (Herfindahl-Hirschman Index, defined below). Their findings indicated that two seed companies in the United States account for 80% and 75% of corn and soybean acres. In meatpacking, the largest four firms in 2019 had 85 percent of steer and heifer slaughter, 67 percent of hog slaughter, and concentration increased over time. They indicated that pre- and post-merger impacts would indicate that the HHI would be from 3200 to 6000.

There were 5-6 firms that control 'most supermarket sales.' They indicated that the CR4 in this sector increased from 13 in 1990 to 33 by 2014, and the HHI increased from 106 in 1990 to 593 in 2019 (Zeballos et al., 2023). The results differed when

[13] The UN rapporteur on extreme poverty and human rights.

analyzed in the metropolitan statistical areas. The average HHI of all food retail sales for the core-based statistical area (CBSA) is 1100 (Ellickson, 2007; Cakir et al., 2020), but when looking at metro-counties, the HHI was 2758 and 5584 in rural counties (Zeballos et al., 2023).

***Concentration in North American Grain Handling*:** For comparison and completeness, the concentration measures were derived from recent data for the U.S. grain handling sector. This data is from Sosland Publishing (2024) and derived for 2024. However, comparable data has been published in prior years (Wilson & Dahl, 1999). The purpose of including these measures is, in part, for completeness. In addition, some previous studies on concentration in international grain trading allege that those firms simultaneously hold dominant positions in the U.S. domestic grain trading sector (e.g., Clapp, 2015).

Over this period, non-majors have drastically increased facilities and capacities in the grain sector. The results are shown in Table 2, including summary measures of the CR4 and HHI (defined below) and a listing of the dominant four firms in each sector. The CR4s are 23, 31, 70, and 23, and HHIs are 255, 518, 1535, and 473 for storage, port, river, and terminal facilities. ADM is the dominant firm in each sector except for the river facilities, in which they are the second largest. The firms following the leader vary in each sector.

The results indicate that the US grain handling sector is "fiercely"[14] competitive. This is particularly true for each storage, port, and terminal facility. The exception is for river facilities approaching a less rival market structure. At HHI values of 2000, the intensity of competition is defined as 'may be fierce or light" (Besanko, 2016). Finally, in comparison to data in 1995, using the same data, the level of concentration has decreased over time (Wilson & Dahl, 1999).

Table 2. US Grain Handling Functions CR4s and HHIs

Function	CR4	HHI	Top 4 Firms
Grain Storage	23	255	ADM, CHS, Cargill, [Gavilon CGB]
Port Facilities	31	518	ADM, Cargilll, CHS, Viterra
River Facilities	70	1535	CGB, ADM, Cargill, Gavilon
Terminal Facilities	34	473	ADM, Andersons, Cargill, [Bunge, Gavilon, Scoular]

Data Sources on International Grain Trading

Data Sources and Interpretation: The data used in this study are observations from individual shipments (nominations) of grains and oilseeds. Thus, each observation is a shipping record associated with an individual shipment. The data were taken from

[14] This term is used by Besanko et al (2016) to define firms with H<2000.

various sources that are generally publicly accessible, in some cases by subscription. These sources included various international shipping agencies, charter companies, etc.[15, 16]

The data were identified as FOB (free-on-board) or CNF (Cost and Freight). FOB shipments are where the exporter sells as loaded on the ship at the origin, and the importer manages and accrues the shipment cost. CNF shipments are where the exporter manages and accrues the cost of shipping to the port of import. This distinction is essential. Individual shipments were identified for each within a line-up of vessels. The shipments are the primary commodities and core seaborne origins of what the global market usually trades/ships. The commodities included are corn, soybean, wheat, and individual vegetable oils. The data does not include small grain flows like barley, sorghum, durum, and some softs, e.g., cotton, pulses, sugar, cocoa, and tapioca.

The data were screened using various factors to accommodate the analysis. First, queries were created to combine subsidiaries under parent companies. An important issue is that many export companies operate under different names worldwide. To make these consistent, we sought corroboration from an international grain trading firm to aggregate reported names to those commonly used in the description of the international grain trading sector. Second, the data were derived from 2015-2023 (calendar years), but due to missing information for some exporting countries (e.g., exporting firms trying to mask their shipments), the results presented in this paper are for 2020-2023. Third, regions of the world were generally taken as consistent with international trade reporting. Finally, the data were screened to eliminate any redundant shipments across sources, if any.

Data on Russian shipments posed problems. One is the rapid change in the industry's structure (described above). The other was many tiny shipments from small autonomous companies across non-conventional routes. For example, in recent years, there have been many individually (several hundred different reported entities) very small shippers reporting small seaborne shipments to neighboring countries (by water). These include shipments from the Russian Far East to China (e.g., Heihe City) and shipments via the Caspian Sea, among others. Individually, these exporters were extremely small.

Data Aggregations and Summary: Several issues were addressed when determining the shipment data. First, many shipments were listed where the shipper or receiver was 'unspecified.' These are shipments where the only source of information was from the inspection agency records (SGS), and these did not provide information on the buyer or

[15] A detailed list of the subscriptions services and agencies is in Appendix A.

[16] Information on commodity flows and shipping is becoming more readily accessible through the growth of varying global vessel tracking and lineup services. Most are now likely in the public domain. Indeed, this is now becoming an important element of trading firms' data analytics.

seller. These are relatively minor: 21% of the FOB and 22% of the CNF shipments were unspecified. There was a higher concentration of 'unspecified' shipments in the EU, Black Sea, and Danube origins in 2023, probably due to shippers wanting to mask their identities.

Second, all shipments were included in defining the total market size (volume) and used to derive the CR4. In summary, the data comprised 62,271 FOB shipments and 48,098 CNF shipments. To verify that the data were representative, we derived the portion of world trade reflected in the data. These are shown in Table 3. The data comprises about 80% of world trade in grains and oilseeds. It is substantial for the major commodities (corn, soybean, and wheat) but a smaller percentage for some other commodities. This is as expected; for the smaller crops, shippers may be more prone not to report details of their shipments.

Table 3. Share of World Trade Captured in the Shipment Data

	Year of ETS			
Commodity	**2020**	**2021**	**2022**	**2023**
Canola Oil	15%	23%	19%	22%
Corn	85%	80%	90%	71%
Palm	76%	90%	78%	66%
Soy meal	76%	84%	85%	67%
Soy oil	64%	76%	70%	62%
Soybeans	94%	96%	82%	86%
Sun Oil	103%	86%	70%	78%
Wheat	75%	87%	75%	74%
Grand Total	**82%**	**86%**	**81%**	**74%**

Results

Data Overview: To provide a high-level description of the data, market shares were derived and illustrated for the firms defined as Majors, Other Majors, and Other grain trading firms. The majors include ADM, Bunge, Cargill, COFCO, LDC, and Viterra. "Other Majors" were subjectively defined to include Aston, CBH, CHS, Gavilon, Grain Corp., Nibulon, Olam, TradeHouse RIF, Wilmar, and about 70 known routine exporters. "Other" was comprised of all other exporters. Market shares were derived for each commodity and specific origins and destinations.

Results are shown in Tables 4, 5, and 6. The origins with the highest market shares for the Majors were Argentina and Brazil, whereas the United States, Australia, and the EU are much less concentrated. Other Majors were more domineering in Australia, Russia and Ukraine. The results are generally true for both FOB and CNF

shipments.[17] Over the period 2020 to 2023, the Majors increased market shares only in Argentina and Canada. For all other regions, the Other Majors and Others increased their shares. The Majors generally had greater shares in the FOB market versus the CNF market.

Concentration by destination (or receiving) countries is fairly homogenous across regions. For FOB and CNF trades, the Major's market shares are in the 20-30% range, with some being lesser. For FOB trades, Other Majors and Others are comparable to the Majors. For CNF trades, Other exporters are more prominent. As noted above, market shares vary across export origins but generally are at values that are not excessive. Notably, concentration in the United States is much less than in competing countries. The concentration varies to a lesser extent across destinations. However, it is apparent that when evaluated at destinations, non-Majors are more prominent.

Table 4. Market Shares by Groups of Grain Trading Firms:By Origin Region (2020-2023)[18]

FOB Shipments			
Origin Region	**Majors**	**Other Majors**	**Others**
Argentina	61%	34%	5%
Australia	31%	40%	28%
Brazil	62%	19%	15%
Canada	42%		31%
European Union	22%	19%	6%
Russia	11%	43%	29%
Ukraine	29%	35%	29%
United States	50%	16%	8%
CNF Shipments			
Origin Region	**Majors**	**Other Majors**	**Others**
Argentina	54%	23%	23%
Australia	19%	60%	21%
Brazil	56%	27%	17%
European Union	12%	5%	8%
Russia	11%	33%	32%
Ukraine	31%	16%	35%
United States	44%	14%	18%

[17] Canada CNF shipments were not reported in the data base by the information source.
[18] The residual from these values would be observations categorized as 'unspecified'.

Table 5. Market Shares by Groups of Grain Trading Firms:By Destination Region (2020-2023)

FOB Shipments			
Destination Region	**Majors**	**Other Majors**	**Others**
European Union	43%	23%	20%
MidEast	37%	27%	21%
North Africa	35%	34%	15%
North East Asia	51%	23%	13%
South Asia	26%	32%	30%
South East Asia	42%	28%	18%
CNF Shipments			
Destination Region	**Majors**	**Other Majors**	**Others**
European Union	48%	10%	18%
MidEast	28%	20%	28%
North Africa	29%	21%	19%
North East Asia	43%	26%	13%
South Asia	27%	12%	11%
South East Asia	34%	31%	16%

There is also variation in market shares among commodities (Table 6). The results are generally comparable for FOB and CNF shipments. Corn and soybeans have more significant market shares for the Majors than wheat. The majors' market shares are 26 and 20 for wheat for FOB and CNF shipments, respectively, which no doubt reflect the large number of other majors and other firms. Much of this reflects the emerging importance of Russia and that of the EU, where the Majors are less dominant. Within the oilseed sector, the Major's market shares are more significant for soybean meal and soybean oil but much less for sun oil, palm, and canola oil. Generally, the Majors market shares decreased from 2020 to 2023. As an example, the market share for corn of the Majors decreased from 57% to 46%. The exceptions are soybean meal and oil, where the Major's market shares have increased.

Table 6. Market Shares by Groups of Grain Trading Firms: By Commodity (2020-2023)

FOB Shipments			
Commodity Group	**Majors**	**Other Majors**	**Others**
Corn	53%	23%	14%
Soybean	55%	20%	10%
Wheat	26%	27%	20%
SoyMeal	54%	25%	15%
SoyOil	45%	39%	9%
SunOil	20%	35%	18%
Palm	3%	34%	45%
Canola Oil	3%	33%	13%
CNF Shipments			
Commodity Group	**Majors**	**Other Majors**	**Others**
Corn	45%	19%	26%
Soybean	47%	25%	14%
Wheat	17%	21%	20%
SoyMeal	57%	20%	18%
SoyOil	78%	8%	8%
SunOil	28%	19%	25%
Palm	0%	0%	0%
Canola Oil	3%	22%	23%

CR4s and HHI: While the above is a summary of the data treating the Majors as an *a priori* group of firms, more appropriate concentration measures are the CR4 and HHI. For this study, CR4 is defined as the simple sum of market shares from the four largest firms. Specifically, CR4 was defined as:

$$CR4 = \sum_{i=1}^{4} s_i;$$

and the formula for the HHI is:

$$HHI = \sum_{i=1}^{n} s_i^2 \cdot 10{,}000;$$

where *n* is the number of firms in the industry, and s_i is the *i*-th firm's market share (ranked from largest to smallest) expressed in decimal format (i.e., 5% would be 0.05). The HHI produces a value that ranges from near zero (extremely competitive industry) to 10,000 (a monopoly). Generally, values less than 2000 suggest either perfect or monopolistic competition market structure, and competition would be 'fierce'; values from 2000-6000 would be an oligopoly, and value from 6000 to 10,000 would be approaching a monopoly (Besanko, et al, 2016). For the derivation of HHI, any export firm with less than 1% market share was excluded. This does not materially affect the derivation of HHI and is an accepted practice in defining concentration (Besanko, et al 2016).

Table 7 summarizes the results for CR4s and HHIs. Figures 1 through 4 show the market shares for each firm from 2020 to 2023.[19] These are shown for all origins and destinations for all specified commodities. Only the top 20 firms are shown in the figures (due to space).

Generally, the market share for the largest four firms is about 30%, but this varies across commodities and countries. The aggregate CR4 for FOB and CNF shipments is 31% and 27%, respectively. The dominant firms are Cargill, COFCO, ADM, and LDC for FOB shipments and COFO, Bunge, ADM, and Cargill for CNF shipments. Thus, there is a difference in market leadership for FOB shipments versus CNF shipments.

The results differ for China's imports. CR4s are higher at 44% and 39%, respectively, for FOB and CNF shipments. Cargill and COFCO are the top firms in FOB shipments, and COFCO and ADM are the dominant firms for CNF shipments.

Table 7. Summary of International Grain Trading Measures of Concentration (2020-2023)

Scope		FOB or CNF	CR4	HHI	Top 4 firms
All Grains & Oilseeds	World	FOB	31	855	Cargill, Cofco, ADM, LDC
		CNF	27	442	Cofco, Bunge, ADM, Cargill
All Grains & Oilseeds	US	FOB	45	1,241	ADM, Cofco, Cargill, Zennoh
		CNF	37	670	ADM, Cofco, Bunge, Cargill
All Grains & Oilseeds	China Imports	FOB	44	855	Cargill, Cofco, ADM, LDC
		CNF	39	769	Cofco, ADM, Cargill LDC
All Grains & Oilseeds	Russian Exports	FOB	33	623	Trade House RIF, Aston, Grain Gates/Mirogroup, United Grain
		CNF	26	408	Solaris, Asont, GTCS, Viterra
Corn only	World	FOB	43	723	Cofco, Cargill, ADM, Bunge
		CNF	36	540	Cofco, ADM, Cargill, Bunge
Soybeans only	World	FOB	45	930	Cargill, ADM, LDC, Bunge
		CNF	38	674	ADM, Bunge, Cargill, LDC
Wheat only	World	FOB	21	343	Viterra, Cargill, Cofco, Tradehouse RIF
		CNF	16	315	CBH, Viterra, Cofco, Cargill

There have been drastic changes in Russian exports in recent years, resulting in Western firms exiting and Russian trading firms becoming more dominant (as discussed above). These results indicate comparable CR4s as above. The results reported here are for 2020-2023, whereas Quinn (2024) reports shares only for 2024. The dominant firms for FOB shipments are Trade House RIF, Aston, Grain Gates/Mirogroup, and United. For CNF shipments, the dominant firms are Solaris, Aston, GTCS, and Viterra. The market structure for Russian exports continues to change with further consolidation of exporters. When evaluated for individual years, for FOB shipments, the CR4 increased from 33% to 44% between 2000 and 2023. TradeHouse RIF was the dominant firm each year, but Cargill fell from the fourth to the eighth largest firm. CR4s for CNF shipments range from 29-35% with no apparent trend. However, the dominant firm shifted from 2020 to 2023, with Aston, GTCS, Solaris, and Grainflower being the

[19] Similar charts for individual commodities are in Appendix B.

dominant firms in each year, respectively. Cargill became much less dominant (at the 8th largest).

Taken together, there have been some notable changes through time. Those of particular importance include 1) the growing penetration of COFCO for CNF and FOB China trades and decreases by Cargill and ADM; 2) radical changes in Russia and reduction in western firms, particularly for wheat; 3) the increase in non-Majors and 'unspecified' in the case of wheat; and 4) the increase in 'unspecified' shippers in 2023, no doubt reflecting the impacts of EU, Black Sea and Danube shipments becoming less transparent.

In general, these results indicate that the international grain trading industry is highly competitive, and in most cases, the industry would be considered as 'competitively fierce.' The competitive fringe[20] component of this market is much greater than previously depicted. From these results and the value of HHI, there is no reason to expect that any firm would be able to exert market power or, taken together, operate as an oligopoly. In all cases, FOB shipments are more concentrated than CNF. Though about 20% of the shipments are unspecified and vary across commodities, these observations would not impact the results so long as they are not concentrated with the dominant shippers.

Finally, the concentration levels reported here are much smaller than in previous studies, which predominantly suggested an aggregate CR4 of 73%. The actual CR4 is much less, CR4s across countries and commodities are much less, and the firms insinuated to be dominant differ. There are several reasons for this distinction. First is the time period. Our period includes the most recent years and summarized across 2020-2023. The most recent publications are unpublished studies from the early 2000s. Much has changed in this industry over this period, notably growth in competitive fringe, including Chinese and Russian trading firms. Second is the scope of analysis. The early studies used data for the US only, and the AWB (2004) study which was the basis for others, used data on revenues which is not relevant. In this study, we use all origins and destinations. Third is the metric. Early studies used export data from the 1970s to 1980s for shipments from the United States. The other most recent study (unpublished) inferred market shares (inappropriately) from revenues of the *a priori* assumed dominant grain trading firms. In this study, we use actual shipments, a more precise measure of trades and concentration. Finally, our analysis reports the CR4 and HHI which is a more appropriate measure of concentration and prospective market power. Earlier studies only reported CR4s.

[20] The term competitive fringe is used here to be consistent with terminology used in the industrial strategy literature. Alternatively, the taxonomy could be referred to as 'layers or tiers' of firms within an industry.

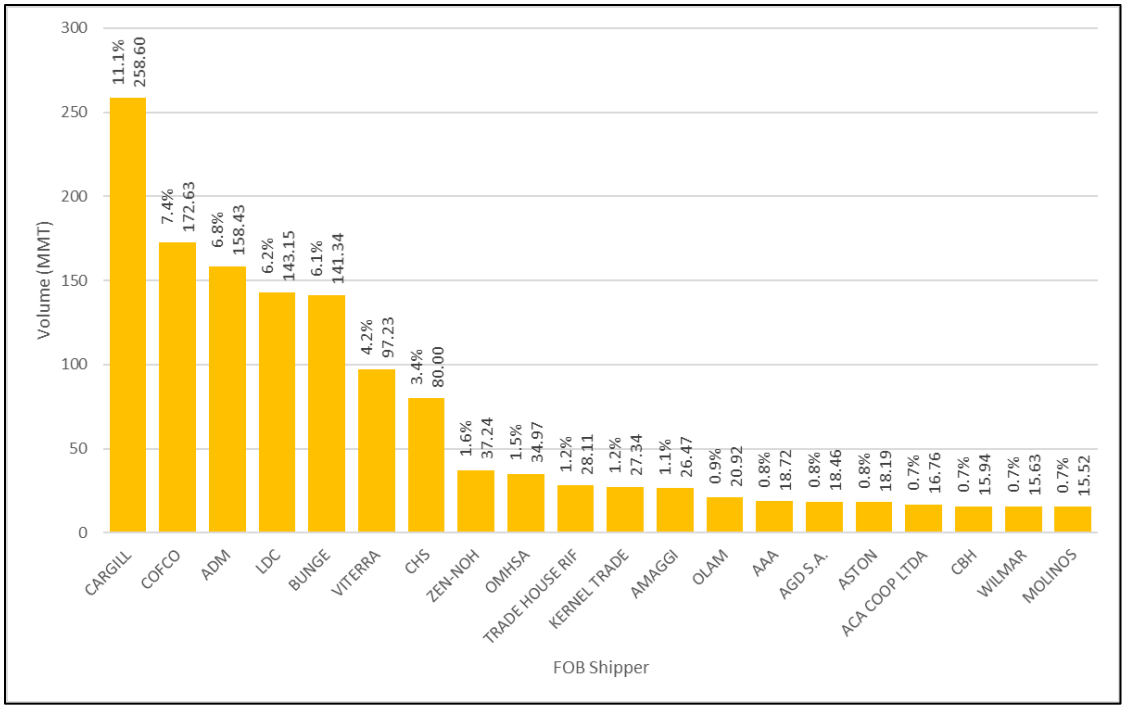

Figure 1. Volumes and market shares for FOB shipments, Top 20 firms, All Commodities, All Origins and Destinations, 2020-2023 (Values for each bar are market share and volume)

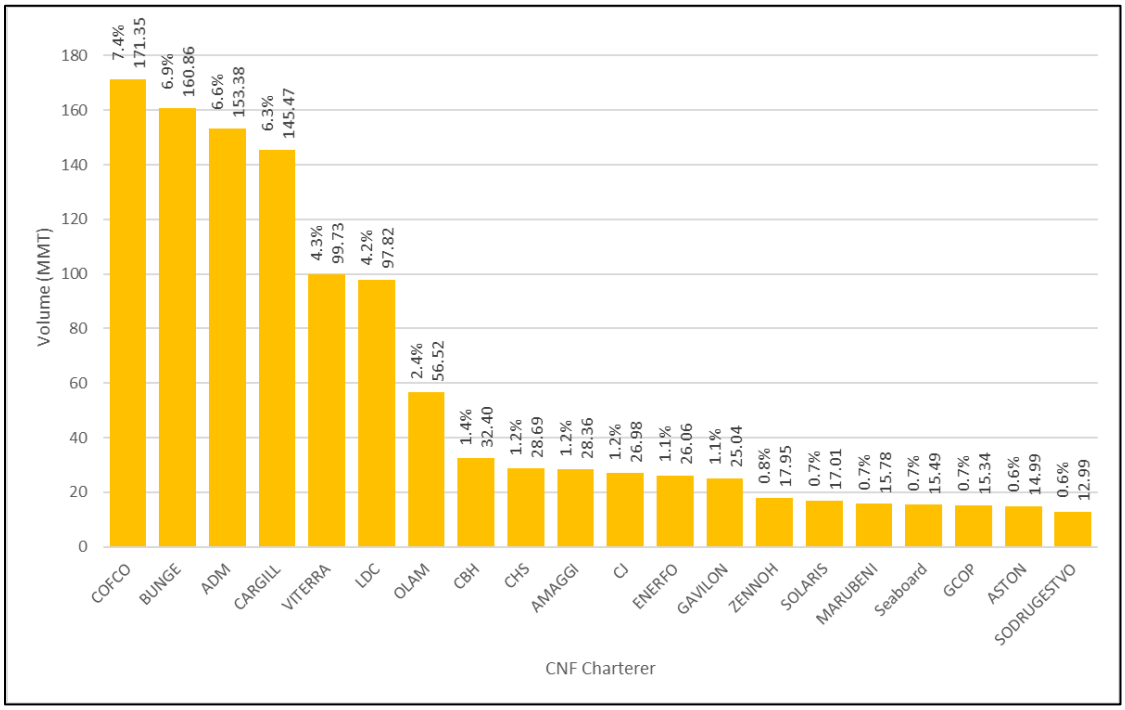

Figure 2. Volumes and market shares for CNF shipments, Top 20 firms, All Commodities, All Origins and Destinations, 2020-2023 (Values for each bar are market share and volume)

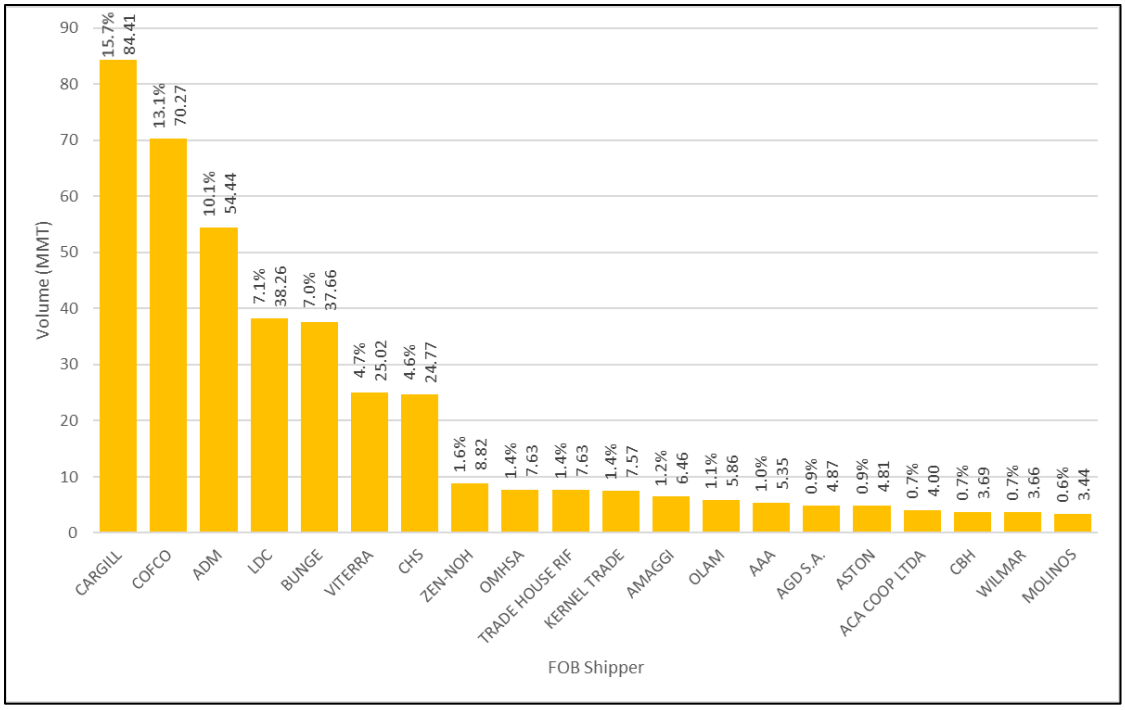

Figure 3. Volumes and market shares for FOB shipments to China, Top 20 firms, All Commodities, All Origins, 2020-2023 (Values for each bar are market share and volume)

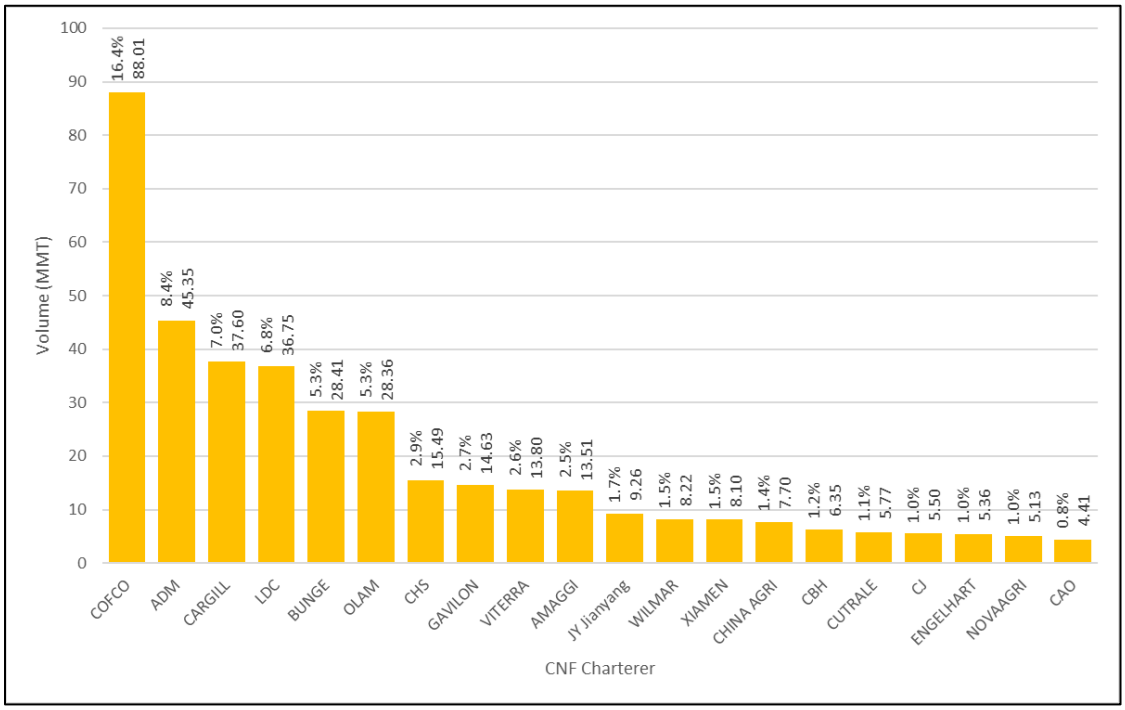

Figure 4. Volumes and market shares for CNF shipments to China, Top 20 firms, All Commodities, All Origins, 2020-2023 (Values for each bar are market share and volume)

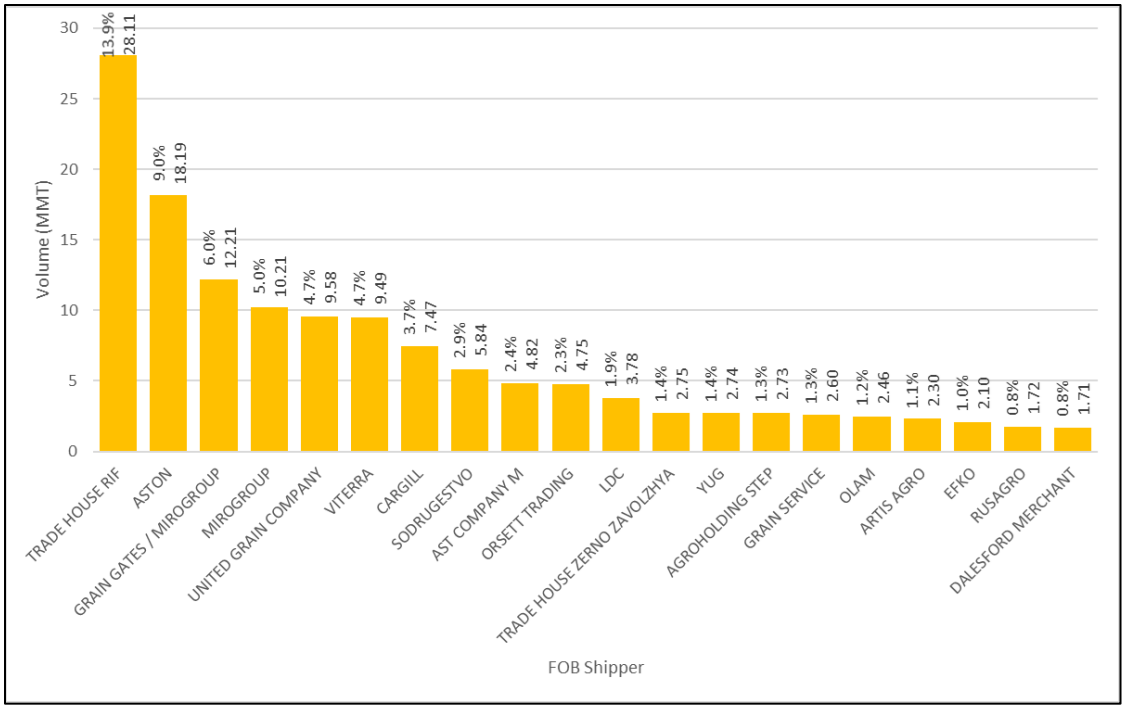

Figure 5. Volumes and market shares for FOB shipments from Russia, Top 20 firms, All Commodities, All Destinations, 2020-2023 (Values for each bar are market share and volume)

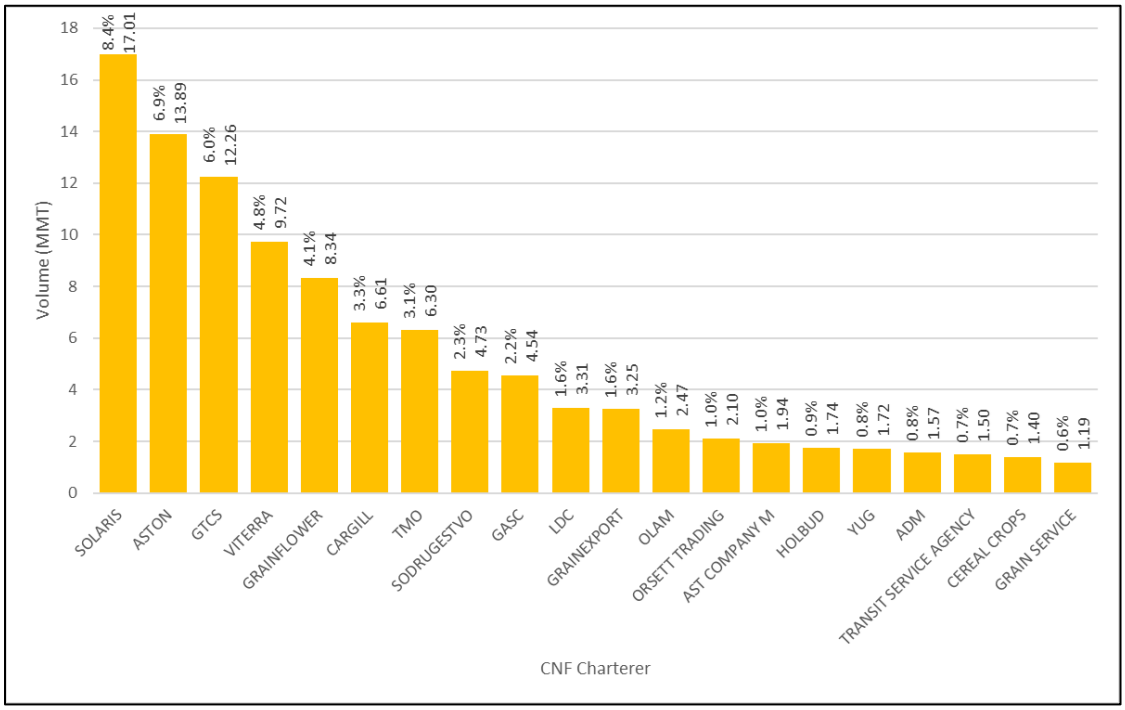

Figure 6. Volumes and market shares for CNF shipments from Russia, Top 20 firms, All Commodities, All Destinations, 2020-2023 (Values for each bar are market share and volume)

Cluster Analysis: Part of the motivation of this study is that over time, the international grain trading industry has evolved to be referred to as ABCD, implying an industry dominated by these four firms. Another interpretation is that a single cluster comprises these four firms. Cluster techniques can be used to more formally and statistically analyze the data to determine the composition of clusters. Cluster analysis is traditionally used to analyze customer market segments and industry analysis, amongst many other applications.

Cluster analysis was used in this study to analyze the structure of the international grain industry and to more formally determine the number of clusters and the composition of firms within each cluster. Several methodologies can be used for cluster analysis. The model used in this paper is k-means clustering, a cornerstone technique in data analysis and machine learning. k-means clustering assumes that the data can be partitioned into a predefined number of clusters, *k*, which allows it to streamline the clustering process and provides clear, actionable insights once the number of clusters is known. The algorithm excels in environments where clusters are spherical and roughly equal in size, as it treats each cluster as a collection of points around a central mean. This assumption simplifies the clustering process and enhances the interpretability of the results, making it easy to identify and understand the structure of the data.

k-means clustering operates efficiently with large datasets due to its iterative refinement approach that quickly converges to a solution. Using Euclidean distance as a measure of similarity ensures that the algorithm effectively groups together data points that are naturally similar, facilitating the discovery of intrinsic patterns within the data. Additionally, k-means clustering is computationally efficient, often providing faster results than more complex clustering algorithms. This efficiency, combined with its straightforward implementation, makes k-means clustering an ideal choice for exploratory data analysis and cluster identification.

In analyzing the clusters of firms in international grain trade, k-means clustering offers a robust method to identify and understand distinct groupings among these firms based on various trade-related metrics. The variables used to delineate clusters include 1) the number of total shipments, 2) the number of origins, 3) the number of destinations, 4) the number of FOB shipments, 5) the number of CNF shipments, and 6) if the firm trades wheat, corn, and soybean. k-means clustering was used to segment firms into clusters that reveal patterns of strategic positioning. The data had four years of data from 2020 to 2023. We tested other variables such as whether the firm trades small grains, the number of shipments over time, other geographic variables, or reliance on specific trade routes, and average shipment size by volume. These additional variables were insignificant to the results and omitted in the final analysis.

The number of clusters was chosen using the Silhouette score which is a measure used to evaluate the quality of clusters created by clustering algorithms. It measures how similar an object is to its own cluster (cohesion) compared to other

clusters (separation). For each point, the Silhouette score ranges from -1 to 1, where a higher score indicates better-defined clusters. A score close to 1 means the point is well-matched to its cluster and poorly matched to neighboring clusters. Conversely, a score close to -1 suggests misclassification. By averaging these scores, the silhouette score helps determine the optimal number of clusters and the overall clustering validity. The K-means algorithm then iteratively assigns each firm to a cluster by minimizing the variance within clusters, effectively grouping firms with similar trade characteristics together. The Python library *Scikit-learn* was used in this paper with its k-means clustering algorithm (Pedregosa et al., 2011).

Applying clustering techniques to the data in this study suggests that the industry may be comprised of multiple clusters or segments, each consisting of firms with similar characteristics. This is consistent with the notion that firm size is important, as is whether the firms are multiple origin-destination trading firms.

The results are summarized in Table 8, and the silhouette scores are shown in Figure 7. The silhouette scores indicate three clusters of firms in the international grain trading industry, i.e., there are three groups of firms that within each cluster that have similar characteristics. Cluster 1 is comprised of seven firms. Thus, in contrast to the normal taxonomy of ABCD, in fact this cluster has seven firms. In addition to ABCD, it also includes COFCO, Viterra, and CHS (ABCCCDV). These firms account for 45% of global FOB shipments, which is less than the CR4's referenced above. This finding is fundamental in understanding the structure of the international grain trading industry. Cluster 2 comprises nine firms with similar characteristics and many other firms, which could be seen as the competitive fringe, a broad segment of similar firms. Finally, Cluster 3 contains many other firms, each individually small.

This is an important finding in understating the structure of the international grain trading industry. Cluster 2 includes nine firms with similar distinctions and a large number of other firms. This could be interpreted as the competitive fringe, a large segment of similar firms. The named firms within that cluster are recognizable in most cases. Finally, Cluster 3 has nine named firms, in addition to a large number of other firms, each of which is individually small.

The characteristics of the clusters are essential. Cluster 1 is comprised of firms that have a large volume of shipments. Shipments by Cluster 1 firms on average are 67X those of Cluster 2 firms; and 107X those of Cluster 3 firms. Cluster 1 firms ship from, on average, 14.4 origins to 92 destinations; shipments include all commodities, including wheat, corn, and soybean. Cluster 2 is similar, except the volumes of shipments are much smaller, and these firms ship from an average of 1.8 origins to 11.9 destinations. Cluster 3 is similar but has a smaller set of origins, but importantly, it does not ship wheat, corn, or soybeans. Firms in each cluster ship both FOB and CNF and in all cases, the number of FOB shipments exceeds the number of CNF shipments. The critical difference between Clusters 1 and 2 supports the importance of size and the ability to be multi-origin and multi-destination shippers.

Finally, since firms in Cluster 3 do not handle wheat, corn, or soybeans, the model was re-run, excluding these firms. The results are an industry of 2 clusters, similar to the clusters reported above. Experimenting with 4 or 5 clusters had low silhouette scores and was not significant.

These results are essential in understanding the structure of the international grain trading industry. First, rather than suggesting one segment called ABCD, in reality, there is a cluster comprised of seven firms with similar characteristics. Second, a large group of other firms differ, but within the group, they have similar structural characteristics. These firms would be the competitive fringe. Finally, there is a large cluster (3) with many small firms which do not handle wheat, corn or soybeans. Taken together, this can be interpreted as an industry comprised of clusters, one of which represents larger firms that ship from a large number of origins to a large number of destinations. The competitive fringe is more complicated as there are two clusters, with a large number of firms. The impact of the competitive fringe has not been mentioned in earlier studies, but as noted here, the competitive fringe is important and has an essential impact on the structure and conduct of the international grain trading industry.

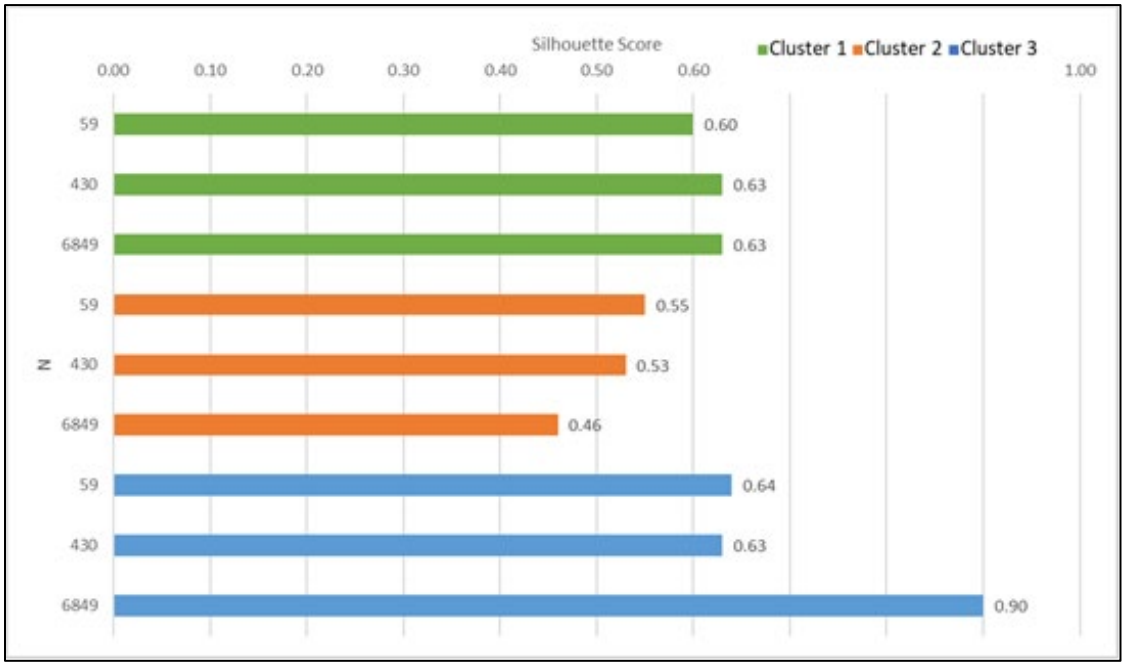

Figure 7. Silhouette Scores for Cluster Evaluation

Table 8. Cluster Results for International Grain Trading Firms

Cluster	1	2	3
n	7	37	15
Silhouette Score	0.60	0.55	0.64
Firms	Cargill	Olam	Agroholding Step
	ADM	Amagg	Prometey
	Cofco	Aston	Profit
	Bunge	Sierentz	Kernel
	Viterra	Ameropa	Grain Gates
	LDC	Gavilon	Solagro
	CHS	Nibulon	Grain Service
		NCH	Enerfo
		CBH	Marubeni
		28 Other Firms	6 Other Firms
Variables	Size of Total Shipments		
	Number of Origins		
	Number of Destinations		
	Number of FOB Shipments		
	Number of CNF Shipments		
	Does the company transport Corn, Soybean, and Wheat?		

Conclusions and Implications

International grain trading is an old industry that has been undergoing radical changes for the past 50 years. There have been major changes in agriculture and policies, changes in factors impacting economies of scale, and an evolving international market environment. Partly in response to these changes, firm strategies have changed. As a result of these changes, there have been changes in the market structure of this industry. This study analyzes detailed data on the structure of the international grain trading industry and documents the evolution of firm and industry strategies.

An escalation in the importance of an evolving competitive fringe has impacted the market structure for this industry. That segment includes many smaller firms, which is important for countervailing market power. The market structure has also been impacted by the emergence and growth of COFCO, a major Chinese grain trading firm charged with importing a share of Chinese imports. However, COFCO has expanded beyond this role in many areas of international grain trading. The radical changes in Ukraine and Russian grain trading firms have also impacted the industry. The latter have increased their share, and Western firms have mostly exited that market.

Strategies for grain trading firms have also evolved. Historically, economies of international grain trading were mostly due to large-scale and onerous information requirements. Each of these had high fixed costs which ultimately precluded entry.

During the 1990s, optionality became important in part as a way to exploit black swan events. Since then, multi-origin strategies have become important and nearly essential to serve customers wanting relationships with suppliers capable of optional origins. Hence, grain trading firms became 'masters of optionality.' During the past two decades, the industry has confronted changes in interior shipping mechanisms, ultimately inducing vertical integration and value-added strategies. The escalation in volatility in futures, basis, shipping costs, and margins has made more risk measurement and management essential. Finally, in recent years, the geopolitical pressures, exacerbated by shortages and climate problems, have resulted in more governmental intervention, which has distorted trade patterns and worsened volatility.

Results: This study used detailed export shipment data for the major traded grains and oilseeds. Two measures of concentration were evaluated: CR4 and HHI. The latter is the most relevant measure of concentration and captures both the effect of the number and the size distribution of firms.

The results indicated that CR4s were 27% and 31% for all commodities from all origins to all destinations. The HHI's were 885 and 442 for FOB and CNF shipments, respectively. The result varied across origins, destinations, and commodities. The CR4s for Chinese imports were 44 and 39% for FOB and CNF Chinese imports. COFCO was the dominant exporter for CNF and Cargill for FOB shipments. In the case of Russia, the dominant firms were all Russian grain trading firms with Western firms being near inconsequential competitors. Finally, there was a slightly greater concentration in export trading for corn and soybean and much less for wheat. The latter is no doubt due to the changes in Russia, as well as those in Australia and Canada.

The dominant firms also differ from earlier studies. For the entire data set, the top four firms for FOB shipment are Cargill, COFCO, ADM, and LDC, whereas for CNF, the top firms are COFCO, Bunge, ADM, and Cargill. Hence, this illustrates that the conventional representation of ABCD is incorrect. Instead, COFCO has become more prominent. COFCO is one of the dominant firms for virtually every sub-aggregation measured, except notably Russia.

These results differ substantially from previously reported studies, which typically report CR4s in 80-90% or, sometimes, 73%. There are important reasons for these differences, including 1) time period, 2) scope of data, and 3) metric. Our analysis uses more detailed data that was not previously accessible for actual shipments, and we derived both the CR4 and HHI.

The overall results indicate that the international grain trading industry is structurally characterized as being competitively 'fierce'. In other words, competition is so intense that the ability of any individual firm to have a perceptible influence on price or trade terms is minimal. This is generally true across the different sub-aggregations of the international grain trading industry. These results are also true for the different grain

marketing functions, at least in the United States. COFCO, Russian grain trading firms, and others appear to be growing in dominance. The largest four firms typically control about 30% of the market.

The data were further analyzed to determine the clusters or segments of the international grain trading industry. The results indicated 3 clusters. Cluster 1 is comprised of seven firms that are very large in shipment volume and ship all commodities from many origins and destinations. The other two clusters had a larger number of firms, and in each cluster, the size of shipments was smaller, and they shipped from a few origins to a few destinations. One of these clusters was characteristically different because it did not handle the major commodities, corn, soybeans, and wheat. Hence, this industry is characterized by 3 clusters. One could be interpreted as the majors, but firms in this sector are greater than the ABCDs. The other is a large segment of small firms which comprise the competitive fringe. Finally, Cluster 3 is a specialist group focusing on vegetable oils.

The result of this study has both private and public implications. For private firms, the results describe the changes in strategies, the emergence of new entrants, and the competitive fringe. The low HHI's indicate fierce competition, ultimately meaning that successful firms must have other strategies to be sustainable. Information is critical, and the ability to analyze information has become more critical due to its being more readily available. Indeed, the data used in this study has now become an essential source of information not previously included in analytical strategy models. Last, it is clear that large firms must have optionality or simply the ability to ship and switch among alternative origins.

The critical public implication is that, in contrast to previous perceptions, this industry's concentration level is low. It is low not only by typical concentration measures but also in comparison to other agricultural sectors. All of the concentration measures suggest that competition is intense and 'fierce'.

This study makes three important contributions. First, it provides a detailed description of the evolution of policies affecting this industry and the apparent changing strategies of firms in this industry. As described, they have changed sharply. Second, it uses a detailed and extensive data set that was not previously accessible or used in this industry. Finally, the results suggest that the concentration level is much lower than reported in previous studies.

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Recent WWW Links on ABCD Concentration:

- https://www.federalregister.gov/documents/2000/03/24/00-4591/united-states-v-cargill-incorporated-public-comment-and-plaintiffs-response
- https://www.acarindex.com/pdfler/acarindex-4349-2893.pdf
- https://www2.econ.iastate.edu/outreach/agriculture/marketing/hayenga/
- https://www.justice.gov/archive/atr/public/press_releases/1999/2554.htm
- https://on.ft.com/46bH2wL
- https://www.bloomberg.com/opinion/articles/2023-06-13/bunge-viterra-grain-deal-your-daily-bread-will-now-come-from-fewer-traders
- https://www.washingtonpost.com/business/2023/06/13/bunge-viterra-grain-deal-your-daily-bread-will-now-come-from-fewer-traders/3833e226-09f6-11ee-8132-a84600f3bb9b_story.html
- https://www.brasildefato.com.br/2018/09/06/report-87-companies-control-world-agricultural-production
- https://medium.com/www-bins-ai/meet-the-behemoths-of-modern-grain-trading-f78957f9f723
- https://pitchbook.com/news/articles/the-abcds-and-ma-putting-90-of-the-global-food-supply-in-fewer-hands
- https://oxfamilibrary.openrepository.com/bitstream/handle/10546/237131/rr-cereal-secrets-grain-traders-agriculture-30082012-en.pdf?sequence=10
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- https://on.ft.com/4ardsWa
- https://www.ft.com/content/481f3646-6b0f-4512-a0f8-f4746fc4c7ab?shareType=nongift

Appendix A: Sources of International Grain Shipping Data

Access to data sources was provided by an international grain trading firm. Each is listed below by country. Some of the sources are confidential, some are by subscription and others are open source.

Ukraine: Stark https://stark-research.net/ ; SGS; Constanta port line-ups; Ukrainian Sea Ports Authority vessel calls database https://data.gov.ua/dataset/f5095ab0-5312-480d-9090-f8f2a42a023c ; Customs data (detailed).

Russia: TBI https://desktop.logisticos.org/; SGS; Customs data (detailed).

Kazakhstan: Customs data (subtotals) https://kgd.gov.kz/ru/exp_trade_files

France: The sources used for Lineups are a conglomeration of different lineups sent by control companies, French ports, port silos, brokers, charterers, French customs or in discussions with other shippers. The data were cross-referenced as much as possible for maximum accuracy.

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EU ex France: SGS

Canada: SGS; PNW pnw@pnwship.com

Australia: ABS; Lachstock

India: Interocean

Palm: For most sources, shipment surveyors. For other countries: Malaysia: official source MPOB Surveyors: Maritime Network, Majorole, ITS, Amespec, SGS; Indonesia: official source BPS Surveyors: Maritime network, ITS, TDL. SSI

South America: Fertimport

United States: Southport/Fertimport

Appendix B: *Ancillary Figures*

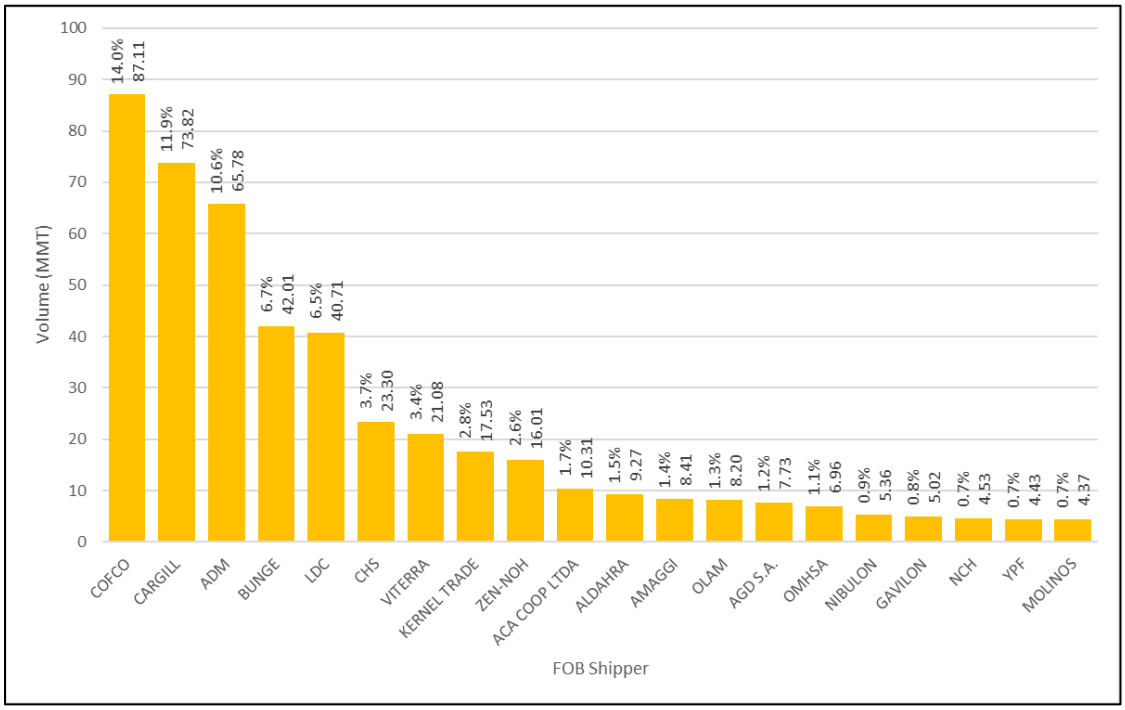

Figure B1. Volumes and market shares for Corn FOB shipments from All Origins and Destinations. 2020-2023 (Values for each bar are market share and volume)

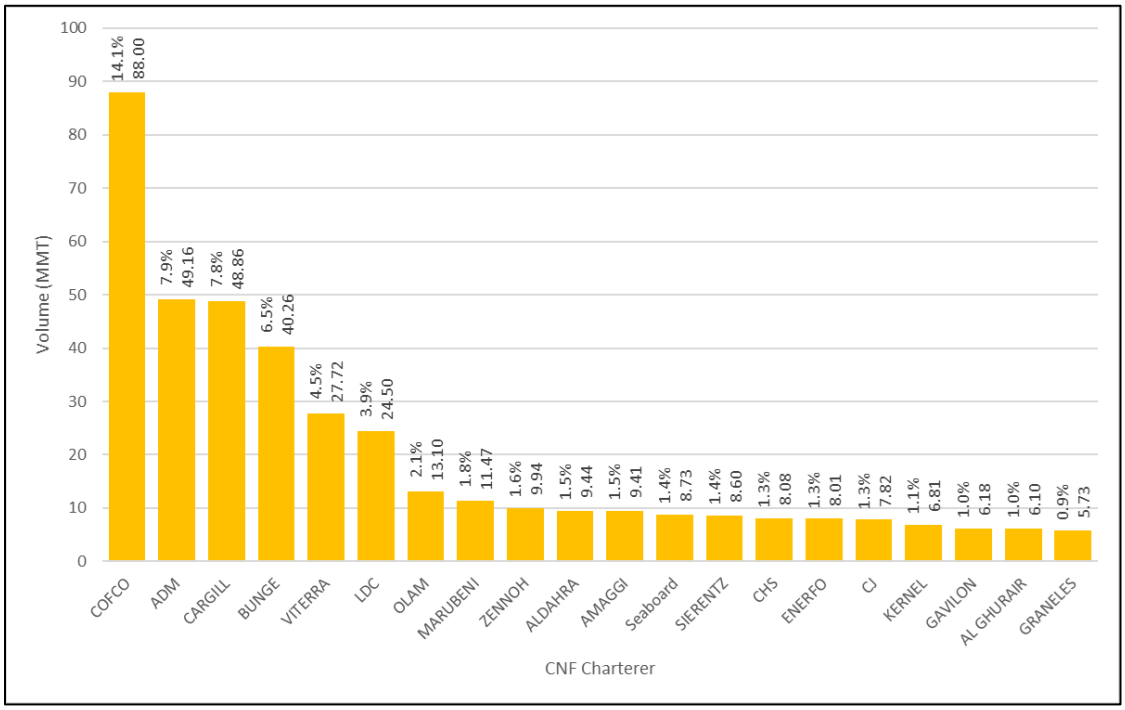

Figure B2. Volumes and market shares for Corn CNF shipments from All Origins and Destinations. 2020-2023 (Values for each bar are market share and volume)

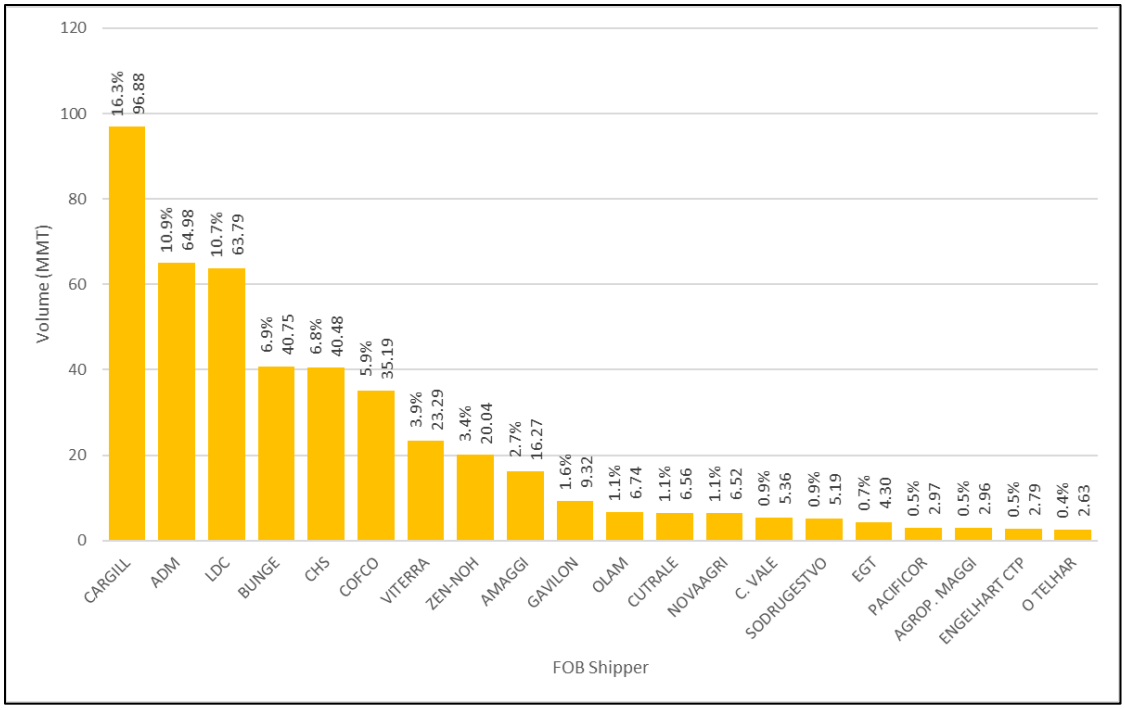

Figure B3. Volumes and market shares for Soybean FOB shipments from All Origins and Destinations. 2020-2023 (Values for each bar are market share and volume)

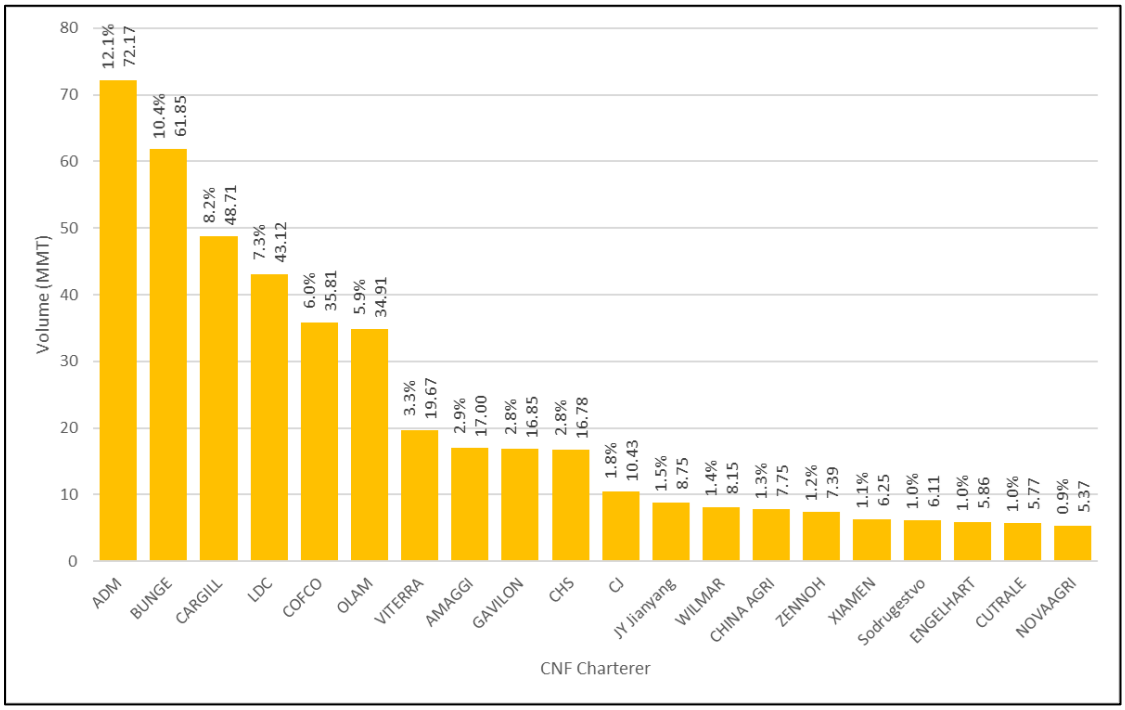

Figure B4. Volumes and market shares for Soybean CNF shipments from All Origins and Destinations. 2020-2023 (Values for each bar are market share and volume)

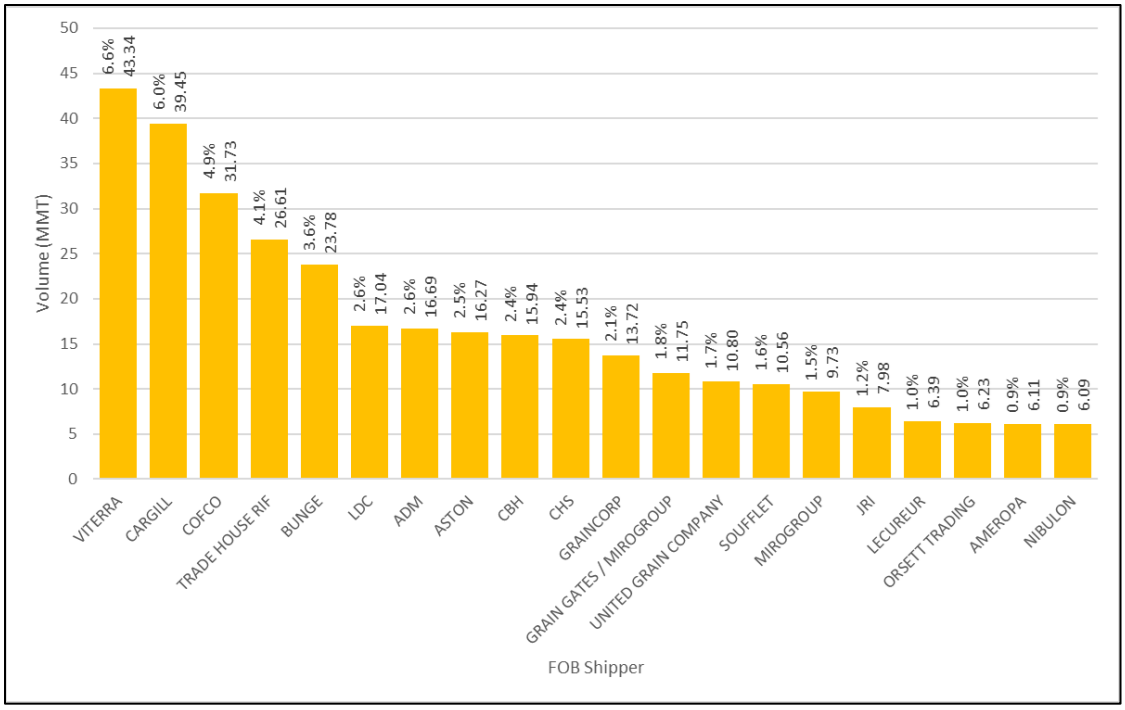

Figure B5. Volumes and market shares for Wheat FOB shipments from All Origins and Destinations. 2020-2023 (Values for each bar are market share and volume)

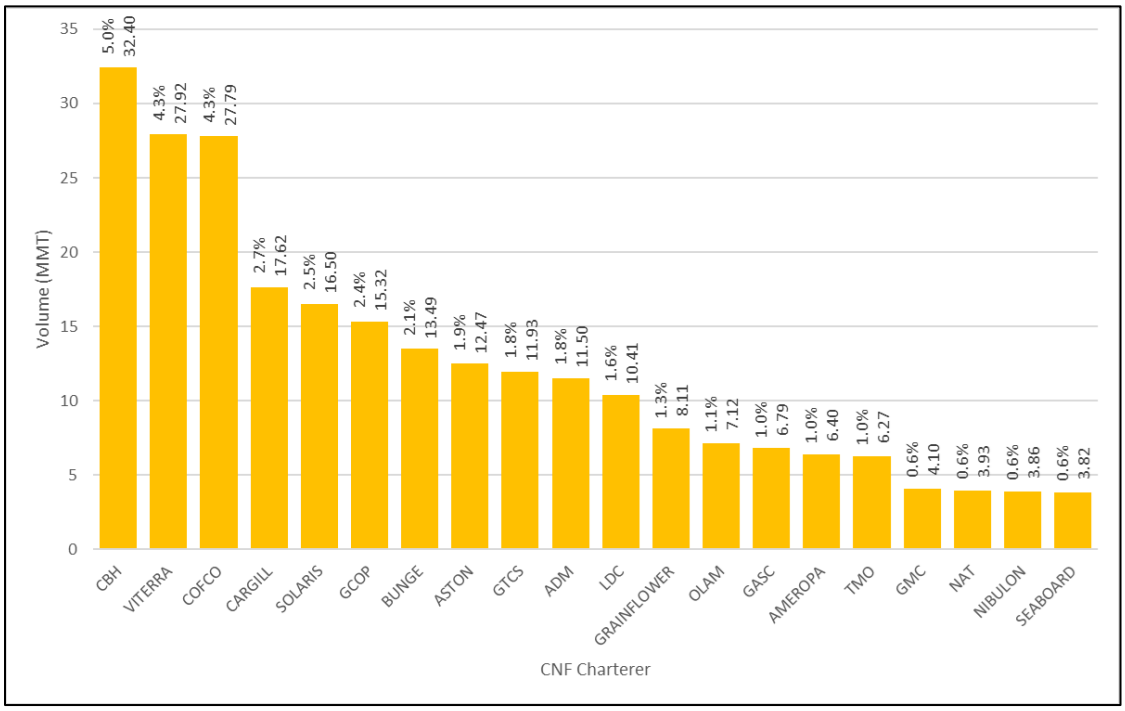

Figure B6. Volumes and market shares for Wheat CNF shipments from All Origins and Destinations. 2020-2023 (Values for each bar are market share and volume)