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The Role of Market Concentration in the Agrifood Industry

Manuel A. Hernández

Alvaro Espinoza

Maria Lucia Berrospi

Koen Deconinck

Johan Swinnen

Rob Vos

Markets, Trade, and Institutions Division
Director's General Office

INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE

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AUTHORS

Manuel A. Hernandez (m.a.hernandez@cgiar.org) is a Senior Research Fellow in the Markets, Trade, and Institutions Division of the International Food Policy Research Institute (IFPRI), Washington, DC.

Alvaro Espinoza (alvaro.espinozah@gmail.com), is a Consultant for IFPRI, Santiago de Chile, Chile.

Maria Lucia Berrospi (m.l.berrospi@cgiar.org) is a Research Assistant in IFPRI's Markets, Trade, and Institutions Division, Washington, DC.

Koen Deconinck (Koen.deconinck@oecd.org) is an Economist/Policy Analyst at the Organisation for Economic Co-operation and Development (OECD), Paris, France.

Johan Swinnen (j.swinnen@cgiar.org) is IFPRI's Director General and Managing Director, Systems Transformation, CGIAR, Washington, DC.

Rob Vos (r.vos@cgiar.org) is Division Director of IFPRI's Markets, Trade, and Institutions Division, Washington, DC.

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Abstract

The role of market concentration and potential market power exertion in the agri-food industry is a topic of longstanding interest and concern to policymakers, stakeholders, and researchers. This study provides a comprehensive overview of recent trends in market concentration upstream, midstream, and downstream the agri-food industry at the global, regional, and country level, and assesses how and to what extent concentration could be affecting market conduct and performance of food systems in developed and developing countries. The analysis additionally discusses, to the extent detectable, implications of concentration, including vertical and horizontal integration that favor concentration, for food security and nutrition and environmental sustainability. While market concentration in the agri-food industry has increased across most segments, the evidence on market power exertion is inconclusive. Several knowledge and data gaps are identified and additional research is necessary to derive more general conclusions and policy recommendations.

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Summary

The role of market concentration and potential market power exertion in the agri-food industry is a topic of longstanding interest and concern to policymakers, stakeholders, and researchers. This study provides a comprehensive overview of recent trends in market concentration upstream, midstream, and downstream the agri-food industry at the global, regional, and country level, and assesses how and to what extent concentration could be affecting market conduct and performance of food systems in developed and developing countries. The analysis similarly discusses, to the extent detectable, implications of concentration, including vertical and horizontal integration that favor concentration, for food security and nutrition and environmental sustainability. While market concentration in the agri-food industry has increased across most segments, the evidence on market power exertion is inconclusive. Several knowledge and data gaps are identified, and additional research is necessary to derive more generalized conclusions and policy recommendations.

What is the current state of market concentration in the agri-food industry?

- ✓ Market concentration in the agri-food industry (from agricultural inputs through the retail sector) has generally increased over the past years.
- ✓ The upstream segment of the agri-food chain is composed of highly concentrated industries, including fertilizers, agrochemicals, and seeds, which show trends of consolidation (i.e., reduction in the number of firms in a market) with important global market players.
- ✓ Several upstream firms have consolidated (benefitting from economies of scale, i.e., saving in unit costs by producing in larger scale) and have presence in multiple countries with subsidiary firms. Some of them further operate their exports through common trading companies, which contribute to concentration in the distribution channel.
- ✓ Markets midstream the chain, particularly food manufacturing and processing industries (that are more developed and consolidated in high income countries while scarce in low income ones), generally show moderate to high levels of concentration that have either increased or remained stable in recent years.
- ✓ The few midstream industries that show low levels of concentration include grain mill and processed meat products, although it is not a general pattern across all major producing countries in each region. For instance, Australia and the US show relatively high levels of

concentration for grain mill products that include breakfast cereals, while Australia and Brazil do the same for processed meats.

- ✓ Downstream, grocery retailers and especially supermarkets, show relatively high concentration levels both in developed and less developed regions, where indicators in the latter can also be moderate to high (or even higher than in developed regions) as is the case of South Africa, Brazil, or Mexico. Similarly, large multinational firms have presence across different regions and exhibit growth and consolidation through acquisitions of local firms.
- ✓ Grain commodity trade is also highly concentrated. There are relatively few companies (trader firms) purchasing bulk agricultural commodities for international trade.
- ✓ Important data gaps remain across industries and regions, which combined with data aggregation challenges (including defining the relevant market in terms of geographical scale and product definition), limit a comprehensive picture of market concentration in agri-food systems and constitute an invitation for devoting more efforts on data access, compilation, and processing.

What factors contribute to increasing concentration in the agri-food industry?

- ✓ Market concentration may originate from multiple factors. Over the past years, mergers and acquisitions combined with the transformation of agri-food chains (including the supermarket revolution) have particularly favored market concentration or consolidation in input agribusiness, food processing, and retailing companies.

Is market concentration per se bad?

- ✓ A typical concern in the industry is that high levels of concentration of market shares among a few large sellers (buyers) may result in market power exertion, imbalance in bargaining power, or tacit collusion that could affect the efficiency of food systems. Yet, the relationship between concentration and market power exertion is complex and the evidence supporting market power abuse is not necessarily obvious and may be context specific. Concentration alone is not sufficient to exert market power or to effectively coordinate strategies among few large market players as this also depends on other market characteristics and contextual factors.

- ✓ Deriving conclusive evidence regarding market power exertion in concentrated markets is thus both theoretically and empirically challenging considering the multiple factors at play that may vary by context and the lack of wide-ranging and detailed data.

What is the relationship between market concentration and conduct and performance in agri-food systems?

- ✓ Studies focusing on midstream and downstream markets in developed economies, for which more data is available, do not find strong evidence of market power exertion, especially buyer power from food processing firms. In developing countries, the literature is scarcer but shows the importance of contextual elements such as remoteness, financial liquidity constraints, credibility, and reputation issues in conferring considerable market power; high transaction costs (e.g., search, storage, contracting costs) can also sharply limit competition as well as local trade frictions (e.g., transportation and other related costs that create price gaps across areas) and lack of appropriate processing facilities. In these contexts, intermediaries can capture large economic rents in detriment of consumers and farmers. The emerging experimental evidence in developing countries is, in turn, mixed, although it is not generalizable as it has largely focused on establishing the relevance of a specific market mechanism or characteristic in the value chain under study.
- ✓ Upstream, high levels of concentration in fertilizer and seed markets, combined with elevated levels of multimarket contact in those industries (where big multinational firms compete with the same rivals in multiple markets) are a matter of concern, including recent record high fertilizer prices (in a context where supply disruptions and export restrictions or bans to one of the few major worldwide producers can provoke immediate impacts on global fertilizer availability and accessibility).
- ✓ As more disaggregated data can be accessed or compiled (including detailed transaction data), new approaches are being developed to better understand the complex relationship between market concentration, conduct, and performance. More research is similarly needed to assess the impact of unfair trading practices (UTPs) along the agri-food chain (not only on farmers), while efficiency and rent distributional implications of some practices are not fully clear. In developing countries, the implications of the transformation of food value chains (including favoring concentration) on market performance could also be studied relying on advanced

empirical industrial organization methods (widely used in developed economies), as more data, including scanner data, become available.

Implications of market concentration for food security and nutrition

- ✓ In rural areas, the association between participation in modern commercialization channels, especially supermarket channels that have increased vertical integration and coordination favoring concentration along the chain, and access to better diets among small farmers in lower income countries appears to be positive, but the literature is still relatively limited to derive more generalized conclusions.
- ✓ The evidence is generally more conclusive on the positive contribution of participation in value chains of supermarkets on rural smallholders' income, consumption expenditure, labor market insertion, and agricultural productivity.
- ✓ In urban areas, the relationship between supermarkets' presence and consumer health and nutrition remains poorly understood. In both developed and developing countries, the evidence is not yet robust enough to be conclusive regarding the positive or negative effect of supermarkets on consumer nutritional status. Part of this ambiguity could be explained by varying driving forces that influence urban consumer food choices, including market competition that has not been encompassed in previous analyses of the linkages between supermarkets and dietary patterns, probably due to the lack of detailed data.

Implications of market concentration for environmental sustainability

- ✓ The literature on the links between market concentration and environmental sustainability can be studied from different perspectives as vertical and horizontal integrations that favor concentration may occur both upstream and downstream the food value chain, which can result in varying competitive practices and environmental consequences.
- ✓ Yet, the current evidence is highly context specific as it pertains to specific market segments, supply chains, or regions. In the seeds sector, for example, the evidence is mixed. Similarly, the literature on food loss and waste (FLW) points out that food waste could be a symptom of structural problems that relate to power imbalances and lack of incentives to minimize food waste.

- ✓ There is an important research gap that could be fulfilled by studying potential environmental effects across different value chains and market segments that are important for the food industry, as well as on the efficient use of resources such as water, land, and energy. The scarce literature in developing countries is also evident where the lack of concentration (or vertical integration) could alternatively be a cause of food waste as smallholder farmers typically do not have the incentives or means to adopt food loss preventive practices, while downstream coordination problems with small-scale operating agents, whose additional lack of sufficient storage, transportation, and processing capacities, could contribute to food losses.

Implications for research

- ✓ While increasing levels of concentration through horizontal and vertical integrations can be associated with higher efficiencies (especially through economies of scale and better coordination), they could also result in anticompetitive behavior in the absence of these efficiencies and other offsetting factors (such as technological efficiencies or pro-competitive gains). Still, the occurrence of mark-up pricing, unfair trading practices, collusion, crowding out of small-scale businesses, lower access to healthy diets, less innovation, and more (or less) food waste may be context-specific and influenced by factors other than concentration. As pointed out above, several key data and research gaps remain, to better understand these relationships and derive more generalized conclusions.

Implications for policy

- ✓ It is important to invest in stronger national and multinational competition authorities and encourage more coordination among them to facilitate the convergence and effective enforcement of antitrust laws at the local, regional, and global level, and ensure that regulations and other policies do not accidentally create barriers to entry, restrain competition, or restrict trade between countries. Yet, it is equally important to keep in mind that guaranteeing competition among agri-food markets will not solve poverty, food insecurity and malnutrition, and environmental issues, such that other, more targeted policies are additionally needed.

- ✓ There is also an important need to expand capabilities of competition authorities to perform more in-depth market studies in specific industries or sectors along the agri-food value chain and encourage the disclosure of more detailed (and frequent) data.
- ✓ With the wide use of new technologies of information, the development of easily accessible virtual platforms (whether through local, regional, or global initiatives) that report relevant market data, promote business (trade) opportunities and access to new markets, or even permit to submit complaints about potential regulatory violations or unfair trading practices, could contribute to increase market transparency and efficiency across different agri-food industries.

1. Introduction

Market structure, defined as the number and type of sellers (buyers) in a market and the nature and level of competition between them, plays a key role in the functioning of agricultural and food markets and can have important implications for prices, product quality and innovation, contractual arrangements along the supply chain, income generation, and welfare distribution. Of particular interest and concern to policymakers, stakeholders, and academics is the role of market concentration and potential market power exertion in agri-food supply systems (IPES-Food, 2017; MacDonald, 2017; Saitone and Sexton, 2017; Sheldon, 2017; Bonanno et al., 2018; Swinnen, 2020; Deconinck, 2021). A typical concern is that high levels of concentration of market shares among a few large sellers (buyers) may result in market power abuse, imbalance in bargaining power, and/or tacit collusion that could affect the efficiency of food systems where these large actors capture most of the rents and alter welfare distribution, especially against poor smallholder producers (and consumers). This raises additional concerns about the implications of market concentration for food security and nutrition and overall environmental sustainability.

However, the relationship between concentration and market power exertion is complex and the evidence supporting market power abuse is not necessarily obvious and may be context specific (Dillon and Dambro, 2017; Lloyd, 2017; Sheldon, 2017; Sheldon, 2018; Swinnen, 2020; Deconinck, 2021). In particular, market concentration may originate from multiple factors. These factors include natural barriers to entry resulting from reduced market size or limited availability of resources and high up-front required investments (e.g., agricultural input markets); natural growth and changing trends among traders, processors, and retailers towards horizontal and vertical integration (e.g., mergers and acquisitions, the "supermarket revolution", contract farming) allowing them to capture larger shares of a market or favoring market consolidation (i.e., a reduction in the number of firms involved in a market); overall changes in consumer demand favoring product differentiation and monopolistic competition (i.e., many sellers competing against each other but offering differentiated products by branding or quality); and policies and regulations (or deregulations) that could restrict market entry or favor concentration among a few major players along the supply and distribution channels of agricultural and food value chains

(e.g., market deregulation in Asia in the 1980s and 1990s that promoted the entry of foreign large companies and reduced space for small local players).

In the case of input agribusiness, food processing, and retailing companies, market concentration or consolidation has occurred through natural growth as well as through mergers and acquisitions (Dobson et al., 2003; Swinnen, 2020; Deconinck, 2019, 2020). On this matter, Barrett et al. (2019, 2021) describe how the transformation of agri-food value chains in low- and middle-income countries occurs from traditional to modern markets and how this relates to concentration. The authors identify three stages of transition: a first stage characterized by traditional spot markets, which are typically competitive with many agents competing on price, volume, and observable quality terms; an intermediate stage with increased inter-firm competition both upstream (commodity procurement) and downstream (retailing), increasing firm pressure to reduce costs and coordinate with suppliers to provide feedstocks and differentiated products that are more highly valued in the target market (Swinnen, 2020); and a modern stage with re-concentration downstream, particularly in the more capital-intensive segments, among a shrinking number of large firms that have become ever more important in the value chain (Swinnen and Vandeplas, 2010). Besides natural barriers to entry, re-concentration can similarly emerge upstream if intellectual property rights confer market power as in the global seed industry today (OECD, 2018a; Deconinck, 2020).

While mergers and acquisitions combined with the transformation of agri-food chains over the past years have favored concentration in the industry, it is also important to keep in mind that concentration *per se* is not inevitably bad and documenting and deriving conclusive theoretical and empirical evidence regarding market power exertion is challenging due to multiple factors at play and lack of wide-ranging and detailed data (beyond prices). Although market concentration (or consolidation) may facilitate coordination between fewer market players (Fraas and Greer, 1977; Baker and Farrell, 2019), concentration alone is not sufficient for firms to be able to exert market power or to effectively coordinate strategies with other actors, or for them to (tacitly) collude as this also depends on other market characteristics and factors, including the type and nature of competition.

This paper provides a comprehensive assessment of the role of market concentration in the agri-food industry. The study reviews the available evidence on market structure (concentration), conduct (behavior), and performance (efficiency and rent distribution) across different segments of the agri-food supply chain and identifies key aspects of agri-food chains that should be considered when examining market concentration and market power relationships. After first documenting global and regional concentration patterns at different segments of the chain, the analysis then focuses on assessing whether market concentration translates into different manifestations of market power, considering the nature of competition between market actors and using concrete examples available in the literature. The discussion on market conduct focuses on an examination whether and how concentration (i) translates into lower buyer prices (i.e., buyer power) or higher seller prices (i.e., seller power), (ii) limits product quality and/or innovation, (iii) promotes unfair trading practices or contracts, or (iv) results in coordination strategies among powerful actors or tacit collusion. The discussion on performance, in turn, focuses on potential impacts of concentration on price margins (markups), profits, and rent allocation. Evidence on the implications for food security and nutrition, including access to healthy diets, and environmental sustainability, including food loss and waste, are also discussed.

Figure 1.1 depicts the segments of the agri-food industry considered for this study. Upstream, these comprise key agricultural input markets (e.g., fertilizers, agrochemicals, seeds), which are highly concentrated global markets that seem to be in a consolidation path; midstream, agricultural production (farming), storage, distribution, and processing that traditionally have shown low to medium levels of concentration, except for food processing and manufacturing where concentration is increasing; and wholesale, retail, and food services downstream that generally exhibit medium to low concentrations, with the exception of retailing (especially supermarket retailing) where concentration is higher and increasing.

Two standard measures of market concentration are (i) the four-firm concentration ratio (CR4), which is the sum of the market shares of the four largest firms competing in a market, and (ii) the Herfindahl-Hirschman index (HHI), which is the sum of the squared of the market share of each

firm operating in a market.[1] To facilitate comparison of concentration patterns across different segments of the agri-food chain and across regions (countries), we focus on concentration ratios, as more data is available allowing to calculate these ratios. In the same vein, we treat these measures as indicators of market structures or the level of concentration in a market, but not necessarily as indicators of the degree of competition or certain market power that requires a more detailed analysis, as extensively discussed in the paper.

Overall, the study aims to inform the Food System Economics Commission on recent trends in market concentration in the agri-food industry and on how and to what extent concentration could be affecting market conduct and performance of food systems, as well as implications for food security and nutrition and environmental sustainability. On this basis, the study provides recommendations for the research and policy agenda and signals knowledge and data gaps to be addressed through further analyses.

The remainder of the paper is organized as follows. Section 2 presents an overview of market concentration across different segments of the agri-food industry based on the most recent available data. Section 3 reviews the existing empirical evidence regarding how and the extent to which market concentration could affect conduct and performance in agri-food systems, while Section 4 discusses the implications of concentration for food security and nutrition and environmental sustainability. Section 5 provides concluding remarks and recommendations moving forward.

[1] The HHI ranges from 0 to 10,000 (e.g., in a market with two firms and shares 60% and 40%, the HHI is 60x60 + 40x40 = 5,200). The main difference between the HHI and CR4 is that the HHI puts more weight on larger firms. All else equal, a reduction in the number of firms in a market leads to a higher HHI, however, this would not occur with the CR4 if the shares of the four largest firms remain the same. The simplicity of the CR4 could thus be a limitation in oligopoly markets with a larger number of firms. In any case, both measures are well accepted in analysis of market concentration, but for its properties the HHI plays a more important role in the assessment of mergers.

2. What is the current state of market concentration across the agri-food industry?

This section presents an overview of market concentration across the agri-food industry. Concentration measures and recent trends are separately described upstream, midstream, and downstream the chain at the global, regional, or country level depending on data availability. Most of the analysis is based on concentration ratios, especially the widely used four-firm concentration ratio (CR4) that is equivalent to the market share of four largest firms in any given market, but measures of the Herfindahl-Hirschman index (HHI), which is the sum of the squared market shares of all firms operating in a market, are also presented when available.

As noted earlier, the measures described in this section should be treated only as indicators of the degree of concentration in a market.[2] They do not necessarily represent indicators of market power, although the level and variations of these indicators, combined with the number of competitors in a specific market, are employed by competition authorities and economists to assess competitive conditions (Kwoka, 2016; Nocke and Whinston, 2022). In the case of the CR4, a market may no longer be considered competitive when four firms have more than 40% of the market share (Shepherd and Shepherd, 2004; Howard, 2016). In the case of the HHI, the US Department of Justice (DOJ) Horizontal Merger Guidelines (2010) classify industries as un-concentrated for HHI less than 1,500, moderately concentrated for HHI between 1,500 and 2,500, and highly concentrated for HHI above 2,500. Typically, industries that are classified as unconcentrated are not subject to DOJ scrutiny, while mergers that would increase the HHI by 100 points or more among moderately concentrated industries can raise competition concerns and are often evaluated; increases by 200 or more among highly concentrated industries are, in turn, presumed to be likely to enhance market power. The European Commission also has horizontal merger guidelines that adopt similar thresholds based on the HHI level and change (Nocke and Whinston, 2022).

It is worth to mention that when applied to studying market competition, the use of indicators for the degree of concentration should always be accompanied by the definition of the relevant market,

[2] The causes of market concentration may also be multiple (as noted in the previous section) and vary across market segments and locations, which requires a more in-depth assessment on a case-by-case basis that is beyond the scope of this study.

which varies depending on the industry considered.[3] As pointed by Crespi and MacDonald (2022), easily available or published measures of market concentration often fail to fully capture economic markets and should be taken as a starting point. Even with disaggregated data, industries may not necessarily correspond to relevant economic markets, either because of too narrow or too broad definitions. In the context of agri-food markets, characteristics like the perishability of some products, the difficulty to transport livestock or the local nature of food retail and grocery stores, difficult defining the geographic scope of a market and is important to be aware of these limitations when analyzing published concentration data.

2.1 Upstream

Fertilizers

The production of fertilizer, as well as other agricultural inputs discussed below, is highly concentrated among a few countries. This is mainly explained by its intense requirements of specific raw materials and the provision of natural gas that are not available worldwide, as well as by economies of scale in production, which generate cost efficiencies for firms (i.e., lower their per-unit costs of production). Several of the major producers are also high-income countries with high trade volumes and comparative advantage in commercialization at the global level.

Using data from International Fertilizer Development Center (IFDC) for 2008-2009, Hernández and Torero (2011, 2013) show that most of the global production capacity for the main fertilizers (ammonia, urea, ammonium nitrate, monoammonium phosphate, MAP; diammonium phosphate, DAP; and phosphoric acid, potash, and nitrogen-phosphate-potassium, NPK, compounds) is concentrated in few countries. Except for ammonium nitrate, the top five countries control more than 50% of the world's production capacity for all these fertilizer products. In the case of potash, Canada and Russia alone are responsible for more than half of the production capacity, while in

[3] In product markets, the relevant market (and the relevant industry) should include all close substitutes and exclude those who are not. In input markets, the relevant market definition must include all competing buyers of a product.

the case of for ammonia, urea, DAP/MAP, and phosphoric acid, China, India, Russia, and the US are among the countries that dominate their production capacity.[4]

Hernández and Torero (2011, 2013) also show a high level of concentration among producers within each main producing country (except for China), which is in part explained by the large up-front investments required that result in economies of scale in production (Kim et al., 2002). In most cases, the top four firms control more than half of each country's production capacity. Concentration of potash production at the country level is the most extreme case: in four of the five main potash-producing countries, the CR4 index is 100%. For DAP/MAP and NPK, four of the five main producing countries exhibit a CR4 over 60%, while for urea three countries show a CR4 over 50%.

Market research data compiled from Euromonitor International (hereafter Euromonitor) permit to depict more recent concentration trends in the fertilizer industry. Using information on company shares for annual production turnover of fertilizers and nitrogen compounds at current prices (in US dollars applying year-over-year exchange rates), market concentration indicators based on country shares in the global market can be calculated by simply adding company shares within each country.[5] According to these calculations, a global CR4 index of 56% is obtained for 2012 (compared to 43% in 1997) with China being the main producer (38%), followed by Russia (6%), India (6%), and Brazil (6%). The global level of concentration peaked in 2015 to 65% and has returned to 56% in 2021 where China (40%), Russia (6%), India (6%), and Brazil (4%) remain as the main producers. Hence, these high levels of concentration at the global level have maintained over the past years with the consolidation of China as the main producer.

At the country level, the CR4 indexes among the top four producing countries have similarly either maintained or slightly increased between 2012 and 2021. As shown in **Figure 2.1**, in India and

[4] The production of phosphate- and potassium-based fertilizers is generally more concentrated than nitrogen-based fertilizers as the availability of phosphate rock and potash deposits is more geographically limited.

[5] Fertilizers and nitrogen compounds comprise nitrogen products associated with fertilizer production (nitric and sulphonitric acids, ammonia, ammonium chloride, ammonium carbonate, nitrites, and nitrates of potassium) and phosphate, potash, and compound fertilizers.

Russia the CR4 index is above 40%, while in Brazil and China it increased from 24.5% and 11.5% to 27.6% and 14%, respectively. The same companies also remain among the top producers in each country and in the same ranking; the only exception is Yunnan Yuntianhua Co Ltd in China that was not among the top four producers in 2012 and became the most important producer in 2021 with a 4.2% of the total volume of sales.

Overall, the fertilizer industry is in a consolidation path with major companies holding important market shares, such as Yara International (Norway) and The Mosaic Company (US) and the recent merger of PotashCorp with Agrium (Canada), combined with a growing importance of manufacturers in the Asia-Pacific region, particularly in China and India. Given the capital-intensive nature of the fertilizer industry, several firms have consolidated to benefit from economies of scale and the size of dominant firms inhibit the entry of smaller companies (IPES-Food, 2017). Several companies also have presence in multiple countries, including subsidiary firms in developing countries, due to cost reductions in gathering or producing inputs (e.g., mining) or for strategical reasons to locate near demand (e.g., Yara International and The Mosaic Company). Similarly, as noted by Fuglie et al. (2011), some of them operate their exports through common trading companies (e.g., Canpotex for PotashCorp, Agrium, and The Mosaic Company and Belarus Potash Company for Uralkali in Russia and Belaruskali in Belarus) that contributes to concentration in the distribution channel and could favor market power exertion.

Agrochemicals

The agrochemical industry also exhibits an important level of concentration. Using firm-level sales data for crop protection chemicals, Fuglie et al. (2011) notes that the global CR4 index in this industry increased from almost 29% in 1994 to 53% in 2009, which, according to this study, is comparable to the trends shown by other agricultural input industries that invest heavily in agricultural research (i.e., seeds, animal health, farm machinery). IPES-Food (2017) further points that the agrochemical industry has been the most recognizable example of consolidation in the agri-food system in recent years, with some of the largest deals in mergers and acquisitions history (both within this industry and expanding to the seed sector), which have additionally renewed a public debate on its implications. Based on 2014 data from the Action Group on Erosion, Technology, and Concentration (ETC), the report remarks that the world's largest agrochemical

corporations at that time, Syngenta (Switzerland), Bayer (Germany), BASF (Germany), DuPont (USA), Monsanto (USA), and Dow (USA), known as the 'Big Six', are linked to the proprietary seed industry, and controlled both 75% of the global pesticides market and 60% of the global seed market.[6]

Similar to fertilizers, market information provided by Euromonitor for the production of pesticides and other agrochemical products permits to compute market concentration measures at the global and country level and visualize more recent trends.[7] Compared to a global CR4 index of 52% in 1997 with the US being the main producer (27%) followed by Japan (9%), France (8%), and China (8%), in 2012 the concentration ratio increased to 64% with a substantial growth from China that concentrated 31% of the global production, followed by the US (16%), Brazil (10%), and Germany (7%). The level of concentration then peaked in 2015 with a global CR4 of 68% and has remained at 63% in 2021 where China (34%), US (14%), Brazil (8%), and Germany (7%) continue to be main producers.

Within each of the four top producing countries, however, the level of concentration has followed different patterns. **Figure 2.2** shows that the CR4 index in China basically doubled between 2012 and 2021 (from 18% to 35.8%), where Wuhai He Ye Chemical Engineering Co Ltd has continued to consolidate its position as the major market player. In the US and Germany, in contrast, the

[6] Seeds became logical and complementary acquisitions for pharmaceutical and chemical corporations investing in biotechnology. Multinational firms – including Bayer and BASF – continue to support cross-sector research in pharmaceutical (human and livestock), chemical and agrochemical applications, while others have been divesting their agricultural units. For example, Pharmacia spun-off Monsanto and AstraZeneca and Novartis spun-off their agricultural unit, Syngenta (IPES-Food, 2017). These interactions with crop protection chemicals are also noted by OECD (2018a) and Deconinck (2020), indicating that seeds and crop protection chemicals can be complements (as with herbicide-tolerance traits and herbicides) or substitutes (as with insect-resistance traits and insecticides), which can have different implications for firms' strategies (Just and Hueth, 1993). Thus, mergers are an effective way of internalizing positive spillovers from investing in complementary products and can facilitate coordination of R&D (Deconinck, 2020). The relative importance of these complementary and substitution effects is therefore essential in order to evaluate the welfare effect of a merger (OECD, 2018a).

[7] Pesticides and other agrochemical reported comprise insecticides and herbicides, plant growth regulators and disinfectants (anti-sprouting products), and fungicides and rodenticides. While the data reported by Euromonitor cannot be disaggregated by each specific sector, it is worth noting that the off-patent herbicide sector has significantly grown over the past years, particularly in developing countries (see also Haggblade et al., 2017).

concentration ratio decreased but still remain over 40%, while in Brazil it has remained around 9-10%.

Seeds

Similar to other agricultural input industries, the seed industry is highly concentrated. Fuglie et al. (2011) indicate that the combined market share of the four largest firms in the global seeds market increased from 21% in 1994 to 54% in 2009, based on firm sales data and an estimate of the overall size of the global seed market.[8] IPES-Food (2017), in turn, report a global CR4 index of 58% in 2011 using ETC Group sales data, which further increased to 65% in 2014, where Bayer CropScience-Monsanto (Germany-US) explains 30.1% of the global sales followed by DuPont-Dow (US), Syngenta (Switzerland), and Vilmorin & Cie (France) with 22.7%, 7.8%, and 4.4%, respectively.[9]

A more recent study on seed market concentration by the OECD (2018a) provides a comprehensive coverage for different seeds disaggregated at the country level. The estimates are based on the overall seed market value, including both commercial and farm-saved seeds (that are more common in developing countries), using data from Kleffmann amis® AgriGlobe® database that covers 65% of the global market value in maize (32 countries), 86% in soybeans (7 countries), 62% in rapeseed (17 countries), and 75% in sunflower (11 countries). Other crops considered, although with a minor coverage, include sugar beet with 43% of the global market value (4 countries), cotton with 35% (3 countries), wheat and barley with 23% (15 countries), and potato with 4% (2 countries).

In the case of maize, the CR4 index is above 60% in 30 of the 32 countries covered and above 40% in the other two countries, while the HHI is above 1,500 in 27 of them; if the indicators are based on volume instead of value, CR4 is over 60% in 28 countries and HHI is above 1,500 in 24

[8] Besides agrochemicals and seeds, Fuglie et al. (2011) examined global market concentration over a 15-year period (1994 through 2009) in animal pharmaceuticals, animal genetics, and farm machinery and find that the largest four firms in these other industries also accounted for more than 50% of global market sales by 2009.

[9] IPES-Food (2017) similarly report high or increasing concentration levels in animal pharmaceuticals, animal genetics, and farm machinery.

countries. For soybeans, the CR4 index is 42% in Ukraine while in the other six countries is above 60% in terms of both value and volume; the HHI is similarly over 1,500 in six of them, while in four countries is above 2,500. For rapeseed, CR4 is above 60% in terms of value in 16 of the 17 countries and above 40% in the remaining country, while the HHI is over 1,500 in 12 countries; in terms of volume, CR4 is above 60% in 12 countries and the HHI above 1,500 in ten countries. Lastly, for sunflower the CR4 index is above 60% across all countries in terms of value and only one country (Russia) has a CR4 below 60% in terms of volume (58%); the HHI in this market exhibits values over 2,500 across most countries.

The OECD (2018a) study also mentions that shares based on volume could be a more representative estimate of market concentration at the global level than shares based on sale values, such as Fuglie et al. (2011) and IPES-Food (2017), because sale shares assign a greater weight to markets with higher seed prices. It is thus difficult to derive a precise estimate of global market concentration as data, when available, varies across countries and market segments that prevent aggregation. In the same vein, Bonny (2014, 2017) argues that value estimates in the seed industry tend to vary across different sources and methods, sales of small and medium-sized firms are often underestimated, and farm saved seeds are not necessarily always included in the estimations; as a result, concentration measures based on under-estimates of total market size could overstate the degree of market concentration. Deconinck (2020) provides additional elements regarding potential shortcomings of global concentration calculations. The author remarks that GMO seeds have much higher unit prices such that these markets could be over-weighted in global estimations (and thereby Monsanto's market share); similarly, a large portion of global seed markets is barely commercialized (e.g., Sub-Saharan Africa, India) and seeds are very context-specific (unlike, for instance, pesticides), so local instead of global market shares can offer more useful statistics.

Bryant et al. (2016) also analyzes the level of concentration for maize, soybean, and cotton seed markets in the US using 2014 and 2015 corporate level data from multiple data sources.[10] Their estimates reveal a very high level of concentration across all three seed markets. The CR4 index

[10] Maize and soybean 2014 data is obtained from Begemann, S. (2015), while cotton 2015 data is obtained from the US Department of Agriculture, Agricultural Marketing Service 2015 Report for "Cotton Varieties Planted" (AMS-USDA, 2015).

is 83% for maize where Monsanto alone has a 35.5% share and DuPont Pioneer another 34.5%. In soybeans, the CR4 is 76.2% where DuPont Pioneer and Monsanto have shares of 33% and 28%, respectively; while in cotton (upland) the CR4 is 91.4% where Bayer has a market share of 38.5% followed by Monsanto with a 31.2% share. These estimates, however, reflect the situation before the merger of Bayer and Monsanto, which also required these companies to divest certain businesses to get the merger approved. Deconinck (2020), using various data sources, elaborate market shares in US upland cotton seed for the period 1970–2017, and notes that publicly available data for this crop makes it possible to track in detail the evolution of market shares over time;[11] based on the author compilation, the CR4 of upland cotton seed in the US has been over 90% since 2000.

2.2 Midstream

Despite the widespread use of market concentration statistics across several industries, reliable data midstream the agri-food chain is relatively scarce, including food manufacturing and processing. For the US, for example, nation-wide concentration ratios for food manufacturing industries are available from Economic Census data that are compiled every five years (Deconinck, 2021). Using these data, Saitone and Sexton (2017) show that, out of the 37 food manufacturing industries covered by the data in 2012, 29 were unconcentrated (HHI below 1,500); five were moderately concentrated (HHI between 1,500 and 2,500); and three (specialty canning, flavoring syrup and concentrate manufacturing, and other snack food manufacturing) were highly concentrated (HHI above 2,500). This trend is confirmed with the latest US Census data, reported in Crespi and MacDonald (2022), showing that out of 35 food processing industries with available data, only five report HHI values over 1,500 where breakfast cereal manufacturing is the most concentrated industry (2,210).[12] Yet, Saitone and Sexton (2017) point out that these nation-wide estimates using North American Industrial Classification System (NAICS) codes to identify

[11] The data sources include OECD (2018a), US Department of Agriculture, Agricultural Marketing Service, "Cotton Varieties Planted" various years (1982–2017), and Fernandez-Cornejo (2004).

[12] Nevertheless, Crespi and MacDonald (2022) similarly present CR4 indicators for 42 food processing industries using the US Census data and show that 23 report a CR4 above 40% and 11 above 60%; some of these industries include: other snack food manufacturing; animal (except poultry) slaughtering; specialty canning; soybean and other oilseed processing; cane sugar manufacturing; and breakfast cereal manufacturing.

industries, are not very relevant for analyzing potential buyer power in agricultural markets, an argument also acknowledged by Crespi and MacDonald (2022). As farm products are often bulky and perishable, the relevant procurement markets are local or regional. The same applies for final consumer products. Detailed information at these more disaggregated scales is generally not available. Crespi and MacDonald (2022) conclude that with this evidence, changes in recent years have been industry-specific, and that the analysis of concentration remains a data-intensive and industry-specific proposition.

Deconinck (2021), in turn, provides estimates of market concentration in the US livestock slaughter for the period 1980-2015, based on various statistical reports from the Grain Inspection, Packers and Stockyards Administration (GIPSA-USDA, 2016), and shows an increase in concentration in recent decades. In particular, the share of steers and heifers slaughtered by the four largest firms increased from less than 40% in 1980 to 85% in the last decade; for cows and bulls, from around 10% to close to 60%; and for hogs, from one-third to around two-thirds. These increasing concentration ratios have additionally raised competition concerns among the US Department of Agriculture and Department of Justice as hog and cattle producers repeatedly mentioned concentration and centralization of meatpacking as an issue (US Department of Justice, 2012). While allegations of anti-competitive conduct by meatpackers have continued, Deconinck (2021) points to empirical research showing that producers may be better off because of lower costs and innovations introduced (Wohlgenant, 2013) or even suggesting that the markets have become more competitive since the 1980s (Ji et al., 2017). As noted earlier, this discussion is connected to the fact that market structure (concentration) itself is not necessarily a good predictor of competitive conditions. This matter is further discussed in the next section.

Estimates for food manufacturing in the European Union are available from the European Commission (2014) study on the economic impact of modern retail. Data for 14 member states in 2012 across 23 product categories, show that baby food, frozen ready-cooked meals, and cereals and coffee exhibit the highest concentration levels, while ham, bread, and cheese exhibit the lowest levels. When averaging across the 23 product categories in each country, the supplier concentration

varies from a HHI less than 1,400 in Germany to over 2,800 in Denmark, with a median of 2,100. In addition, average concentration increased between 2004 and 2012 across most countries.[13]

Comparable data for other regions and countries are generally difficult to find, although for some countries or industries detailed studies exist. In Mexico, Deconinck (2021) refers to a 2015 study by the Federal Economic Competition Commission (COFECE) that reports estimates of concentration levels at various stages of the agri-food chain using economic census data. The study shows that concentration appears to vary considerably by product category as in the US and Europe. For instance, the estimated HHI is less than 1,500 for sugar cane, vegetable oils and fats, cookies and pastries, among others; moderately concentrated markets include beer, prepared foods other than frozen foods, and condiments and dressings; and highly concentrated markets includes snacks, breakfast cereals, and industrial baking. The report similarly stresses that HHI estimates based on census data may underestimate true market concentration in some markets.

In sum, publicly available estimates of market concentration midstream the food chain should be analyzed with caution as they may not capture the relevant market. This is further emphasized by Deconinck (2021) who indicates that this not only applies in terms of geographical scale (i.e., procurement markets for agricultural products will rarely parallel with national or regional market definitions used in Census data) but also for product definitions, because product categories used for concentration estimates in food manufacturing are not always the relevant ones from the farmers' perspective.

Market data from Euromonitor also permit to depict recent concentration trends for selected product categories in food manufacturing and processing that include dairy, grain milled products, and meat and meat products.[14] Annual company shares are available from 2012 through 2021 for several countries based on production data (at manufacturer selling price). For illustrative

[13] The study also provides more detailed information for selected countries based on country-specific studies.

[14] Dairy products comprise butter and spreads, cheese, drinking milk products, yoghurt and sour milk products, and other dairy; grain mill products comprise grain milling and breakfast cereals; and meat and meat products comprise red meat, white meat, and red and white meat products.

purposes, the most important market (i.e., country with the largest production) is selected in each region and product category.

Figure 2.3 plots the evolution of the CR4 index for dairy processors among the selected countries. Except for Brazil and Russia, the concentration ratios are above or close to 50% and have generally remained rather stable or increased over time. China shows an 8.5-percentage points (pp) increase (from 46.9% in 2012 to 55.4% in 2021), followed by South Africa with a 7pp increase (from 53% to 60%), Australia with a 5pp increase (from 58.3% to 63.3%), and Saudi Arabia with a 2.9pp increase (from 51.5% to 54.4%). In Germany the ratio has remained rather stable at 49-50% while in the US it decreased from 58.3% to 53.6%.

Figure 2.4 depicts the evolution of the CR4 index for grain milled products. For this product category, only Australia and the US exhibit important levels of concentration. In the case of Australia, the CR4 maintained around 74-75% between 2012 and 2021 while for the US it increased from 50.9% to 56.5%. For the remaining countries (Turkey, Brazil, Russia, and China), the concentration levels are below 20% and have remained rather stable over the last decade.

Finally, **Figure 2.5** presents CR4 trends for meat and meat products. Australia also exhibits in this case the highest level of concentration, although it decreased from 67.6% in 2012 to 57.3% in 2021, followed by Brazil with a relatively stable CR4 of 43-44%. The other countries show concentration ratios below 30% that have generally maintained steady over time, except for Saudi Arabia that increased from 20.6% to 27.8%. In the US and Germany, CR4 indexes situate at 27.8% and 23.6%, respectively, in 2021, while China barely has a concentration ratio of 10.7% and Russia of 4.6%.

2.3 Downstream

Downstream the agri-food chain, most of the available information focuses on the retail sector in the US and EU, where particularly food retailing was a largely fragmented sector until the 1980s (Dobson et al., 2003). In the UK, for example, the leading five firms controlled only 8-9% of national retail goods sales in 1961 and 14.4% by 1982 (Swinnen and Vandeplas, 2010). The real

consolidation wave of the retail sector in the US and EU largely took place in the 1990's (Swinnen, 2020). In the US, the combined market share of the four largest grocery retailers increased from 14% in 1984 to 22% in 1994 and 55 % in 2001 (Swinnen and Vandeplas, 2010). Einarsson (2007) similarly reports that by 2004 in the Nordic countries the market share of the largest three retailers in the grocery market was already 79.6% in Finland, 81% in Iceland, 82% in Norway, and 91.2% in Denmark and Sweden.

More recent estimations confirm that the high level of concentration in the retail sector generally persists, which has also been a matter of concern (especially in the US and Europe). Using US Census data up to 2013, Saitone and Sexton (2017) show that the four leading grocery retailers have a combined share of close to 40% of the national market (compared to less than 20% in 1992). In several large US cities, CR4 indexes are even 60% or higher, pointing to larger concentrations at the local level. A similar trend is observed in small nonmetropolitan and rural areas, as reported by Crespi and MacDonald (2022) using data from US counties that show an increase in food retail concentration between 1990 and 2015.[15] In Europe, the European Commission (2014) study on the retail sector notes that the market share of the largest five food retailers reached over 80% in the 2000s. By 2012, the HHI varied from less than 1,200 in Italy to more than 3,900 in Finland, with a median of around 2,000. Yet, in contrast with concentration among food manufacturers, average retail concentration saw a decline between 2004 and 2012 in 16 of the 26 member states for which data are available, due to growth of retailers who had a small market share in 2004 or were not even present (such as discounters), but in the other ten member states retail concentration increased (European Commission, 2014).

An up-to-date study of the retail sector in the US, performed by the Economic Research Service of the US Department of Agriculture (ERS-USDA, 2021a), remarks that the total food sales of supermarkets, other grocery (except convenience) stores, warehouse clubs, and supercenters reached 653 US billion dollars in 2019, and the concentration of sales among the largest retailers has been on an upward trend after the 2007-2009 recession. More specifically, the share of food

[15] The average HHI for food retail increased from 2,071 in 1990 to 3,075 in 2015 in rural counties and from 1,617 to 2,924 in non-metropolitan small urban counties (Data from USDA, Economic Research Service and Çakır et al. (2020) using National Economic Time Series (NETS) data).

sales by the top four retailers have been continuously growing from 31% in 2012 to 34% in 2019. A contributing factor to this rising trend over the past decade has been the steady growth of Walmart Supercenters, making Walmart the largest US retailer of grocery products, followed by Kroger, Albertson's, and Target. In addition, Kroger, the largest traditional retailer, has been a major player in mergers and acquisitions activities, acquiring important retailers such as Harris Teeter and Roundy's over the past decade, while Albertsons' acquired Safeway (another important retailer) in 2015.[16] Overall, more than 300 food industry mergers and acquisitions were recorded in 2019 in the US.

Available data for grocery retailers and supermarkets in Euromonitor also allows to show concentration trends between 2012 and 2021 for selected countries across the world.[17] The estimates are based in this case on annual company shares using sales data (at retailer selling price). Similar to the midstream figures, the country with the largest grocery store or supermarket sales is selected in each region.

For grocery retailers, **Figure 2.6** shows important (over 40%) and somewhat increasing concentration levels among several countries. As in food manufacturing and processing, Australia reports the largest CR4 in grocery retail (from 74.4% in 2012 to 78.6% in 2021), followed by South Africa (from 47.2% to 54.3%), France (around 50%), the US (around 40%), and Russia that reached 40.2% in 2021 (exhibiting a 23.8pp increase relative to 2012). Of the remaining countries, the CR4 increased from 32.5% to 35.8% in Mexico and from 14.1% to 19% in Saudi Arabia, while in China the concentration ratio remained at 3%.

For supermarkets, there are even higher levels of concentration that in several cases have further increased over time, depicting the consolidation of this sector. As shown in **Figure 2.7**, In

[16] Another important recent acquisition was that of Whole Foods by Amazon in 2017, although the overall market structure of the retail sector was not largely affected as Amazon was not a major player in the industry (ERS-USDA, 2021a).

[17] Grocery retailers comprise retailers selling predominantly food/beverages/tobacco and other everyday groceries; these include hypermarkets, supermarkets, discounters, convenience stores, independent small grocers, chained forecourt retailers, independent forecourt retailers, food/drink/tobacco specialists, and other grocery retailers. Supermarkets comprise retail outlets selling groceries within a selling space of 400-2,500 square meters; excludes discounters, convenience stores, and independent grocery stores.

Germany, Australia, and South Africa, the CR4 index reached 96%, 89.6%, and 81.5%, respectively, in 2021 reflecting increases of 4-7pp from 2012. In the US and Saudi Arabia, CR4 levels reached around 40% in 2021, compared to 31% in 2012, while in Brazil the concentration ratio has remained relatively stable at 40-41%. Russia also shows an important increase from 12.1% to 22.8%, whereas in China the level of concentration is barely 3%.

The food service industry is another large and growing sector downstream the agri-food chain. In the US, for instance, this industry was larger than food retailing until 2019 (prior to the pandemic). According to ERS-USDA (2021b), full-service and fast-food restaurants, the two largest segments of the commercial food service market in the US, account for about 74% percent of all food service outlets in 2020. Food service companies are major customers of wholesalers that distribute specifically to this industry and do not necessarily compete with food retailers for customers. Instead, food service distributors offer value-added services designed to meet the needs of single-store restaurants and small chains. Two firms, Sysco and US Foods (formerly U.S. Foodservice), dominate this broadline distribution in the US with over 70% of the market (AMS-USDA, 2022); in 2015, Sysco's planned merger with US Foods was dropped after being blocked based on antitrust grounds.

Globally, the fast-food industry is a highly fragmented market composed of a few large and many small competitors. The market was worth 972.74 billion US dollars in 2021 and is projected to increase to 1,467.04 billion US dollars by 2028 due to a growing number and variety of quick service restaurants in developing and developed countries, increasing tourism, expanding millennial population base, and dual-working households, and despite increasing awareness of health issues related to fast food consumption (Fortune Business Insights, 2022).[18] The US alone has close to one third of the global fast-food market share, while the burger and sandwich segment dominates the world market (explaining almost 36% of the market share) due to the presence of burger chains in most countries, followed by the pizza and pasta segment. According to an industry report by T4 (2021), the leading fast-food chain in the market is McDonald's with 21.4% of total revenues in 2018, followed by Starbucks with 7.5%, and KFC and Subway with 2.8% each.

[18] For instance, the number of quick-service restaurants in the US increased from 285,000 in 2000 to 340,000 in 2015.

The high concentration in the international distribution and commercialization of grains also deserves some discussion. There are relatively few companies (trader firms) purchasing bulk agricultural commodities for international trade. The four major corporations that produce, process, transport, finance, and trade food and agricultural commodities (known as the ABCD): ADM - Archer Daniels Midland (USA), Bunge (USA), Cargill (USA), and Louis Dreyfus Commodities (France), are estimated to account for up to 90% of global grain trade (Murphy et al., 2012). A more recent estimate of the combined 2016 revenues of ABCD traders plus the two big emerging firms from Asia, COFCO Group (China) and Wilmar International Ltd. (Singapore), is 365 billion US dollars, a figure that far exceeds the combined global markets for seeds, agrochemicals, farm equipment, and fertilizers, according to IPES-Food (2017).[19] Hence, agricultural (grain) commodity trade is highly concentrated, while much data remain proprietary and companies continue to globalize and diversify their activities.

All in all, the upstream segment of the agri-food chain is composed of highly concentrated industries, including fertilizers, agrochemicals, and seeds, that appear to be in a consolidation path with important global market players. Markets in the midstream of food supply chains, particularly food processing, as well as those further downstream, especially supermarket retailing, similarly show moderate to high levels of concentration (and consolidation in some cases) that have either increased or remained stable in recent years across several countries in different regions. The international distribution and commercialization of grain also shows high levels of concentration.[20] In the next section, we extensively discuss the implications of concentration on market conduct and performance in the agri-food industry, considering that this high and/or increasing concentration has been a matter of recurrent concern, particularly in the US and Europe, over the past years.

Despite the estimates and trends presented above, it is worth noting that important data gaps remain across industries and regions that prevent a more comprehensive picture of market structure in agri-food systems. IPES-Food (2017) point out difficulties in accessing detailed firm and market

[19] COFCO Group is China National Cereals, Oils and Foodstuffs, a state-owned company.
[20] See **Table 2.1** for a summary of all figures and estimates of concentration discussed in this section.

data, which constitute a major obstacle in examining concentration of power in the agri-food industry. The study further remarks that the available analyses are typically geographically incomplete. There is, for example, a disproportionate presence of US and UK companies on global markets and emerging technologies but limited disaggregated data to understand their domestic and global roles.[21] Lack of detailed data (including historic data) also limits understanding of the growing influence of leading companies from the Global South (e.g., China, India, Brazil). In the same vein, Fernandez-Cornejo and Just (2007) and Mammana (2014) indicate general difficulties in obtaining market share data at a disaggregated level (when examining the seed industry). These data shortcomings, combined with the issues outlined above regarding data aggregation challenges or complications, including the use of different variables for analysis (e.g., shares based on volume versus sales) or defining the relevant markets across segments in the agri-food chain, are certainly an invitation for devoting more efforts on data access, compilation, and processing.

It is fair to indicate, however, that competition authorities do not necessarily have difficulties in obtaining disaggregated market data. In many jurisdictions, these institutions can conduct market analysis on their own initiative, and in some cases even compelling testimony. Following a roundtable discussion on market studies held in 2008, the OECD and the UK launched a project in 2014-2015 to provide support to competition authorities from several countries in Latin America and the Caribbean in their use of market studies as a competition tool, and in developing a legal framework.[22] Furthermore, with the release of the Market Studies Guide to Competition Authorities (OECD, 2018b) and the exchange of experiences between competition authorities, the topic has continued to trigger interest in recent years. Additional to regular functions held by the authorities, the goal of these market assessments is to verify if competition is working efficiently and identify measures to address issues detected. These measures comprise recommendations such as proposals for regulatory reform or improving information dissemination, and they can also include the opening of antitrust investigations.

[21] Howard (2016) notes that 22 of the 40 largest food companies around the world are US- or UK-based companies.
[22] Chile, Colombia, Costa Rica, Mexico, Panama, and Peru. More information about the OECD work on market studies is available at: https://www.oecd.org/daf/competition/market-studies-and-competition.htm.

3. Market concentration, conduct and performance in agri-food systems

Inferring a causal relationship between market structure (concentration), firm conduct, and performance is generally a difficult empirical task. Since the pioneer work of Demsetz (1973), which was later articulated as an empirical problem by Bresnahan (1989), economists have advanced from "structure-conduct-performance" studies in favor of alternative approaches, considering the necessity to correctly address problems of endogeneity, simultaneity, and causality between modeled market equilibrium outcomes (O'Brien, 2017; Berry et al., 2019; and Miller et al., 2022, provide a recent discussion).[23] Despite methodological challenges and data limitations, there is a general agreement that while increasing levels of concentration, including mergers, can be associated with higher efficiencies (through, e.g., economies of scale), they could also result in anticompetitive behavior in the absence of these efficiencies and other offsetting factors (e.g., technological efficiencies or pro-competitive gains),[24] whether through unilateral or coordinated actions (effects) (Hovenkamp and Shapiro, 2018; Nocke and Whinston, 2022).

In this section, we present key aspects and findings from the up-to-date literature that examine the effects of concentration on conduct and performance across markets upstream, midstream, and downstream the agri-food chain. Special attention is paid to potential market power exertion

[23] To illustrate these problems, note that both prices and quantities (market shares) depend on demand, supply, and the underlying factors that drive them. Economic theory indicates that these variables are jointly determined in equilibrium, which implies that a regression analysis of, for instance, price on market concentration, does not show the sort of causal effect that a researcher would aim; the regression estimate would pick up various possible correlations that occur due to variations in underlying demand and supply factors (e.g., income shocks, cost shocks). This non-causality is a different and more fundamental problem than endogeneity or simultaneity. In the problem of endogeneity, a clear causal path between prices and concentration can be established by a particular economic model but the causal factor (in this example, concentration) can also be correlated with unobserved factors not accounted for in the regression analysis. The problem of simultaneity occurs, instead, when the causal variable is simultaneously determined by the variable on the left side of the regression (in this example, price), as in the classic economic model of supply and demand. Practitioners have developed many possible solutions to both problems of endogeneity and simultaneity, which in different situations might include controlling for additional factors in a regression or using what are called instrumental variables. However, these solutions do not solve the sort of problem presented by a regression where there is no causal relationship to be estimated (O'Brien, 2017; Miller et al., 2022).

[24] Kolasky and Dick (2003) provides a historical progression of how efficiencies are considered in merger analysis in the US, recognizing that they should play a central role in merger review.

reflected in traditional conduct outcomes such as price or quality;[25] in coordination strategies among powerful actors (or tacit collusion); in the prevalence of unfair trading practices (UTPs), which is an issue of increasing concern especially in Europe;[26] and in performance indicators such as price margins (i.e., markups or differences between sales and purchase price) and profits.

3.1 Upstream

Fertilizers

Kim et al. (2002) analyze trade-offs between market power and cost efficiency in the US nitrogen fertilizer industry, using data from 1976 to 2000. The industry is characterized as a price-leadership model for oligopolistic competition (i.e., where there is a dominant firm among the few firms in the market) and the analysis shows that market power costs outweigh (by 55%) the benefits in terms of manufacturing cost efficiency associated with economies of size from increased concentration. The authors note that strong market power effects have implications for the stability of both the nitrogen fertilizer supply and farmers' revenues, as production is lower and the price paid by farmers is higher than if the market operated under perfectly competitive conditions. In their view, long-term contracts by fertilizer producers do not necessarily lead to a stable supply at a relatively low price; as natural gas price rises, which is the most important production cost, nitrogen fertilizer producers may be better off by selling their contracted natural gas rather than producing fertilizers, putting supply at risk.

Hernández and Torero (2013) examine the fertilizer industry at the global level and assess the relationship between market concentration and prices. The authors note that despite the fertilizer industry is already highly concentrated, in further concentrated markets prices are even higher, which could limit fertilizer access to many smallholder farmers. Using annual data on urea prices and market shares for a panel of 38 countries for 1970-2002, the authors perform some simulations to show the potential positive effects of increasing global and regional competition in the industry

[25] In the case of a seller firm, market power refers, for example, to the capacity of the firm to set a price above marginal cost, while in the case of a buyer firm it refers to the capacity to pay the supplier a price below the marginal product value (i.e., behaviors that deviate from perfect competition conditions).
[26] An EU directive was adopted in April 2019 to regulate unfair trading practices in business-to-business relationships in the agricultural and food supply chain (EU Directive 2019/633).

on agriculture in low-income countries, which are highly dependent on imported fertilizer. For instance, a 10% increase in competition could increase fertilizer use by 13% to 19% and rural incomes by 1% to 2% in regions such as sub-Saharan Africa. Considering that local fertilizer distribution channels in developing countries are similarly characterized by a small number of traders, Hernández and Torero (2018) supplement earlier results discussing partial correlations between market concentration and price margins in Kenya. Using data collected in 2016 through interviews with wholesalers and retailers in major market centers across Kenya's Central and Western regions, the authors find a positive correlation between local market concentration and wholesale and retail price margins for different fertilizer products (CAN, DAP, NPK, and urea).[27] As more data become available, the authors encourage a closer look at the fertilizer industry and the relationship between concentration and prices in order to obtain a better understanding of competitive behavior along global, regional, and local supply and distribution channels that can help prevent potential market power exertion.

Likewise, the global fertilizer market has been showing unique record high prices over past major events. During the food price crisis of 2007-2008, the price spikes in the fertilizer industry were much higher compared to commodity prices in energy and agricultural markets (Hernández and Torero, 2013). In 2021-2022, fertilizer prices have spiked again and more than tripled in real terms since the start of the pandemic (while grains less than doubled) due to surging input costs, supply disruptions, export restrictions and sanctions, and the Russian invasion of Ukraine. This has upped concerns about fertilizer availability and accessibility, which heavily depend on a few major producers worldwide (see above), and, hence, the impact fertilizer shortage may have on global food security (Glauber and Laborde, 2022; Hebebrand and Laborde, 2022). Baffes and Koh (2022) expect fertilizer prices to remain high for some time to come. These exceptional price hikes, combined with past industry reports from Green Markets indicating record profits by leading fertilizer producers (with joint total revenues of over US$50 billion per year),[28] invite for a more in-depth assessment of fertilizer firm behavior.

[27] CAN stands for calcium ammonium nitrate, DAP for diammonium phosphate, and NPK for complex fertilizer (nitrogen, phosphorous, potassium).
[28] Green Markets, fertilizer market data, www.fertilizerpricing.com.

Seeds

A study from the OECD (2018a) provides a comprehensive assessment of the effects of market concentration on prices and innovation in the seed industry based on disaggregated cross-country data for various crops, including cotton, maize, potato, rapeseed, soybeans, sugar beet, sunflower, and wheat and barley.[29] The statistical analysis using various specifications do not find clear evidence of a positive association between market concentration and seed prices, after controlling for crop-specific and country-specific effects on prices. According to this study, apparent structural differences in price levels between countries could be explained by quality differences and the presence of public plant breeders in some markets, besides varying market concentration levels. In the case of innovation, while there is a positive association between market size and innovation in plant breeding (number of new market entries),[30] the role of market concentration is less clear: the partial correlations are all imprecisely estimated and vary across specifications.

The study similarly reports a considerable degree of multimarket contact (i.e., overlap between the same group of players in different markets), which is worth paying special attention;[31] a high degree of overlap between the same firms across different markets could increase the likelihood of (tacit) collusion between firms as well as reduce the contestability of markets by diminishing the likelihood of entry by outsider firms (Bernheim and Whinston, 1990; Fernandez and Marin, 1998).[32] The data and analysis presented by OECD (2018a) covers mostly developed countries and some emerging economies, so for most developing and least developed countries, information

[29] Data availability for prices comprises several EU Member States and a selection of countries from North and South America (United States, Mexico, Brazil, Uruguay, Paraguay, Argentina), Oceania-Asia (Australia, Philippines, Thailand, Indonesia) and Africa (South Africa). In innovation, the analysis is focused on the EU.

[30] Marketing of seeds in the EU requires the variety to be registered in the national list of one Member State.

[31] The degree of multimarket contact seems to be higher, for example, for maize, rapeseed, and sunflower seed but lower for wheat and barley. Unfortunately, limitations on their dataset made it difficult to assess the impact of multimarket contact on seed prices, as the dataset does not have full coverage across crops and countries. The authors further note that any empirical measure of whether firms have contact across different markets would tend to understate the true level of multimarket contact.

[32] The study also remarks that in the context of the seed industry, multimarket contact can occur across several dimensions: firms in the seed industry can compete in agrochemicals (or even in non-agricultural products); firms competing in one geography may also face each other as competitors in other geographies; firms competing in the seed market for one crop may also compete in the seed market for other crops.

regarding market concentration or the potential impact of recent mergers in the seed industry on market outcomes is scarce.

Bryant et al. (2016) perform model-based simulations of mergers in the seed industries for maize, soybeans, and cotton in the US. While their method has some limitations (as discussed in OECD, 2018a),[33] the findings suggests that price increases tend to be greater in markets where the combined market share of the merging firms is higher, which points to a positive correlation between concentration and prices. The results further indicate that firms with smaller initial market shares are more likely to raise prices the most after merging.

Çakır and Nolan (2015) developed a theoretical model with both an input and complementary input sector upstream and an output sector downstream that can help to better understand the implications for producer and consumer welfare of market power exertion upstream the agri-food chain.[34] The authors compare market power exerted in the complementary input versus downstream sector and find that market power exercised by the supplier of the complementary input generates greater negative welfare effects than the same level of market power exercised by downstream firms. The intuition for the result comes from the differences between the information available to downstream firms and suppliers of complementary inputs or complementors. As downstream firms can exert oligopolistic power by using their knowledge of demand for the composite commodity and/or oligopsony power by using their knowledge of supply for the primary input, complementors can exert oligopolistic power by using their knowledge of derived demand, which comprises information on both demand for the composite commodity and supply for the primary input. Compared to the welfare distribution under perfect competition, the oligopolistic power exercised by complementors generates greater welfare losses to consumers and producers than welfare losses stemming from an equivalent degree of oligopoly or oligopsony

[33] Some caveats in the analysis include the high level of aggregation (the US as a single market) and assumptions that only the merging firms will increase their prices or that other factors (e.g., product choice or innovation) remain unchanged.

[34] The model focuses on a primary input sector, which consists of numerous suppliers (upstream firms), and allows for exertion of market power in a concentrated complementary input sector (complementors) as well as in the downstream sector (downstream firms producing a composite commodity using the two inputs). The model setting is an oligopoly/oligopsony for a homogeneous good in an imperfectly competitive market assuming Cournot (quantity) competition with symmetric firms.

market power from downstream firms.[35] Their results are discussed in the context of the Canadian grain-handling and transportation system, showing that benefits from regulation in that sector could potentially accrue to downstream firms more than to upstream suppliers for whom the regulation intended to achieve competitive outcomes.

3.2 Midstream

McCorriston (2014) summarized the literature in the context of the 2013 OECD Roundtable on Competition Issues in the Food Chain Industry (OECD, 2014), and concluded that "[e]mpirical evidence on the existence of buyer power is generally lacking."

A more recent compilation by Perekhozhuk et al. (2017) includes 38 studies on buyer and/or seller power in agricultural product markets, and only find modest deviations from competition in most of their conduct parameter estimates; the relatively low magnitude of supply elasticity estimates (i.e., implying that a demand reduction has a large impact on farm prices) explains why several studies tend to find large price effects, but only modest levels of market power.[36] The reviews by Sheldon (2017, 2018) also conclude that there is little robust empirical evidence of food processing firms exerting buyer power. Similarly, Sexton and Xia (2018) point out that empirical studies "have tended to find only mild departures from perfect competition". Nonetheless, they argue that today's market characteristics are not consistent with standard economic model assumptions and "likely cause market power to be less than would be predicted based on the highly concentrated structures of many modern agricultural and food markets." In a review of competition issues in agri-food value chains, Swinnen (2020) notes that there is "mixed" evidence of a systematic problem of buyer power at the expense of farmers. Deconinck (2021) reviews 42 relevant empirical studies regarding buyer power affecting farmers (16 of them not considered in earlier works by

[35] Or equivalently, for the same degree of market power, the welfare consequences from complementors' oligopoly power are the same as those due to the downstream firms' combined oligopoly and oligopsony market power.

[36] In the studies reviewed by Perekhozhuk et al. (2017), buyer power is exerted by restricting purchases to farmers in order to lower prices. The estimated price effect is thus a combination of the overall level of demand reduction and the impact the reduced demand has on farm prices (captured by the elasticity of farm supply). If farm supply is highly inelastic (i.e., the supply is not much affected by the price at which farmers are able to sell their product), even a small demand reduction could result in large price effects, as appears to be the case in the studies reviewed.

Perekhozhuk et al. (2017), Sheldon (2017, 2018), and Sexton and Xia (2018)) and only finds evidence of economically significant levels of market power and/or price distortions in some of them, as in the Greece food supply chain (Kaditi, 2012).[37]

As Perekhozhuk et al. (2017) and Sexton and Xia (2018) highlight, the different methods to estimate price markups are based on different assumptions such that the resulting estimates can also differ significantly. Koppenberg and Hirsch (2021) note that if these assumptions are potentially inaccurate, estimates for market power and the resulting predicted welfare effects can be biased and recommendations for policy makers may be inaccurate. Sexton and Xia (2018) consider that the most promising methods to obtain reliable market power estimates avoid either estimation of conjectural elasticities and market conduct parameters or avoid estimating cost parameters.

There are also several studies estimating (asymmetric) price transmission across the chain and its relationship with market power.[38] In an edited volume on price transmission in agri-food markets, McCorriston (2015) concludes that the evidence regarding asymmetric price transmission is mixed and varies between sectors and periods, and there is no strong evidence of its association with buyer concentration. For example, in an empirical analysis of the Germany dairy sector, Holm et al. (2012) find substantial asymmetric price transmission, but the authors do not find a correlation with the strength of a brand (a proxy for market power), while the impact on profits is limited. A similar mixed conclusion is reached in the price transmission studies reviewed by Swinnen and Vandeplas (2015), but their conceptual framework is additionally helpful to understand that an important shortcoming in the price transmission literature is the assumption that factor markets

[37] Kaditi (2012) finds that buyer power is exerted to some extent by all firms in the supply chain in Greece, including the (relatively large) agricultural firms in her sample based on data from nearly 3,000 companies between 1998 and 2007. Her estimates show that food processing firms reduce prices by around 14%, while the corresponding wholesalers' and retailers' estimates are 27% and 42%, respectively.

[38] Broadly, this literature tests if price transmission depends on whether prices go up or down, and the hypothesis is that concentrated businesses in segments of the value chain can take advantage of differential effects (i.e., asymmetric pass through of prices) to extract rent. Deconinck (2021) discusses that at least when it comes to deriving conclusions on market structure, a limitation of this literature is the lack of a price transmission and market power link in theory. The review of price transmission research in the food chain (both empirical and theoretical) performed by Lloyd (2017) concluded that "[t]heoretical analysis highlights the fact that, without careful consideration of the range of factors involved, little can be inferred about market power from the low (or high) value of the price transmission coefficient alone".

work well and that contracts are enforced, and vertical coordination and search and monitoring costs are often ignored. The authors argue that these factors are widespread and are not only present in less developed regions, but also in many sectors in modern agri-food value chains where search costs can be significant. In the same vein, the authors stress that vertical constraints and supply chains that require contract-specific and critical investments by buyers rule out the traditional assumption that weaker price transmission is associated with lower supplier welfare, such that the belief that powerful intermediaries in the supply chain are capturing rents is no longer applicable.

As pointed out by Deconinck (2021) and more recently by Crespi and MacDonald (2022), the US meatpacking industry has received special attention over the past decade with an important number of studies examining the effects of concentration on market outcomes, including studies commissioned by the government, due to persistent anti-competitive allegations concerning important players in the industry.[39] Yet, a review of this literature concludes that concentration in procurement of livestock (cattle or hogs) has not adversely affected prices received by producers or prices paid by consumers. There is evidence that producers may be actually better off because of lower processing costs due to concentration and introduction of technical innovations (Wohlgenant, 2013). A more recent work by Ji et al. (2017) is consistent with these findings, and further suggests that markets have become more competitive since the 1980s (despite higher levels of concentration). In the same industry in Canada, an empirical analysis by Rude et al. (2011) shows that market conditions did not deviate from competitive conditions between 1992 and 2001, in line with earlier studies which similarly did not find evidence of market power as long as

[39] Over the past months, the US meatpacking market has regained political attention. On July 2021, President Biden issued Executive Order (EO) 14036, "Promoting Competition in the American Economy", and in the ensuing months, federal agencies have begun to implement several initiatives to address competition issues across the economy, including a more competitive meat and poultry supply chain. On January 2022, the US Department of Justice and US Department of Agriculture issued "Shared Principles and Commitments to Protect Against Unfair and Anticompetitive Practices", including a statement that commits to jointly develop a centralized, accessible process for farmers, ranchers, and other producers and growers to submit complaints about potential violations of the antitrust laws and the Packers and Stockyards Act; and to vigorously enforce the laws that protects them from unfair, deceptive, discriminatory, and anticompetitive practices (available at: https://www.justice.gov/opa/pr/justice-department-and-agriculture-department-issue-shared-principles-and-commitments-protect). On March 2022, the US Department of Agriculture announced a supplemental funding to promote competition and create more markets for local and regional food producers by expanding and strengthening opportunities to sell to institutions, e.g., universities, hospitals (available at: https://www.usda.gov/media/press-releases/2022/03/01/usda-announces-supplemental-american-rescue-plan-funding-available).

Canadian producers had the option of shipping live cattle to the United States; however, they did find evidence of buyer power during the temporary ban on Canadian live cattle imports into the US in May 2003 (after a case of bovine spongiform encephalopathy in Canada).

In a wide-ranging study that covers several elements relevant for the analysis of agri-food value chains in low- and middle-income countries, Barrett et al. (2021) point out that most studies on market power in agri-food value chains have focused on developed economies. The study includes a review of the empirical literature for developing countries' agri-food distribution markets, and remark that the degree to which perfect competition or market power prevails has been one of the longstanding preoccupations. Within very localized areas, competition typically prevails, although remoteness, financial liquidity constraints, and associated credibility and reputation issues can confer considerable market power in niches that require significant capital or are characterized by non-trivial economies of scale or scope, especially long-haul, large-scale trading (Dillon and Dambro, 2017; Casaburi and Macchiavello, 2019; Bergquist and Dinerstein, 2020; Casaburi and Reed, 2017, 2022). Aspects like high search, storage and contracting costs can sharply limit competition over longer distances and across seasons, limiting spatial and inter-seasonal competition (Barrett, 1997; Moser et al., 2009). In these contexts, intermediaries can take large surpluses in detriment of consumers and farmers. Barrett et al. (2021) emphasize that across different countries and periods, food marketing intermediaries are typically distrusted as predatory agents rather than celebrated for facilitating welfare-enhancing transactions, while the low quality of infrastructure and long distances in many markets can indeed foster market power.[40]

Another important dimension of potential market power abuse studied in the agri-food industry are UTPs and their impact on farmers, although the evidence is mainly anecdotal and, in most cases, outdated (Falkowski, 2017). UTPs are various types of practices that can be linked with abuse of market power and can be classified into four categories: i) the retroactive misuse of unspecified, ambiguous, or incomplete contract terms; (ii) the excessive and unpredictable transfer of costs or risks of a trading partner to its counterparty; (iii) the misuse of confidential information; and (iv) the unfair termination or disruption of a commercial relationship (Swinnen, 2020). In most surveys to farmers reviewed by Di Marcantonio et al. (2018), the majority of respondents have

[40] Intermediaries, however, may also bear large operating costs.

experienced one or more UTP, but as Sexton (2017) remarks the surveys generally collect the view of one party of the transaction, which difficult assessing the problem from a more comprehensive perspective. Deconinck (2021) adds to this problem that the definition of UTP can vary across countries, and not all UTPs are equally common or severe. For example, nearly all (98%) dairy farmers from France, Germany, Poland and Spain surveyed in Di Marcantonio et al. (2018) reported at least one UTP;[41] by comparison, the share of respondents reporting experiencing UTPs during or after contract execution is considerably lower.[42] To further inquire in this finding, estimations using the aforementioned survey of dairy farmers, presented in the work by Di Marcantonio et al. (2020), show that contract completeness increases the likelihood of farmers reporting that their contracts with processors include practices that may be considered as UTPs and, in contrast, contract completeness does not seem to affect UTPs during the contract execution or its termination. According to the authors, these results support the hypothesis that surplus extraction is generally done through the inclusion of specific contract terms, while given the signed contract, UTPs are much less likely during contract execution and its finalization.

Deconinck (2021) also notes that in surveys regarding the prevalence of UTPs, the rates obtained in EU countries are relatively high. In addition, the author remarks that several in-depth studies of competition authorities have found instances of UTPs in agri-food sectors across numerous European countries (Bulgaria, the Czech Republic, Germany, Latvia, Poland, Slovenia, and Sweden), as well as in the wine grape sector in Australia. The study discusses a recent proposal to improve knowledge on UTPs, based in Russo (2020), that combines a broad-scope empirical analysis across sectors within each country (e.g., with a general survey) and more in-depth studies for specific sectors (e.g., using expert panels to design sector-specific surveys), including interviews and economic analysis to achieve a more efficient monitoring system for UTPs. More information can further help to better understand the actual impact of UTPs on consumers and

[41] Specifically, almost 90% of farmers reported that the contract does not define any safeguard for the farmer if the buyer fails to fulfil the contract, while close to 20% of farmers reported that the price is set unilaterally by the buyer in the contract. Deconinck (2021), however, remarks that having an incomplete contract could not be considered itself an UTP, and the same applies for the price being unilaterally set by the buyer (Sexton, 2017).

[42] For example, only 2.7% of farmers reported that the buyer unilaterally changed the price; 1.2% reported a unilateral change in required quality; and 1.5% reported a unilateral change in required quantity. These figures are remarkably low in a sector where UTPs were thought to be common.

suppliers and disentangle if some practices described as unfair, may in fact have an ambiguous economic effect. For instance, no consensus exists in the literature regarding how efficiency and income distribution are affected by certain forms of market power conduct, such as "reverse margin" practices (Falkowski, 2017).[43]

Swinnen (2020) similarly discusses the evidence regarding the effects that requirements of standards can have on welfare, as a way dominant firms could gain additional market power. The author exemplifies this situation noting that suppliers are often confronted with a limited number of buyers willing (or able) to reward high standards because these (and the associated quality premiums) are, for example, company-specific (Henson, 2006; Smith, 2009). Thus, effects on efficiency attributed to solve asymmetric information problems can be offset by market power gains and implementation costs of the standard or label (Bonroy and Constantatos, 2015), such that conclusions regarding aggregate effects are mixed. Swinnen (2020) add that most studies do not focus on the distribution of welfare between producers and consumers but rather on total welfare. Only a few explore the effect of labels on the distribution of surplus, such as Bonnet and Bouamra-Mechemache (2016) that consider the effect of an organic label on the share of surplus created along the value chain between manufacturers and retailers with an explicit discussion of bargaining power.

Certain modern commercial relationships (e.g., contract farming or participation in supermarket channels) tend to enhance market concentration and vertical integration of the agri-food chain. Research of such relationships in developing countries has led to recommendations that public policy should be supporting the establishment and maintenance of this type of contractual arrangements, especially when involving small-scale farmers. Such recommendations stem from the evidence provided by those studies that inclusion and participation in contractual arrangements, even in regions with different agro-ecological conditions, crops, characteristics of buyers' firms and contracting practices, tends to (i) increase households income (Reardon et al., 2009; Miyata et

[43] "Reverse margin" practices are contractual clauses which require a supplier to pay a fee to the buyer, for example, in exchange for services offered by the buyer such as promotional activities. Deconinck (2021) recall that both theoretically and empirically it is less clear whether such practices negatively affect efficiency. If a stronger party can negotiate a more advantageous price, it is unclear why it would resort to additional contract terms to extract more surplus if doing so has a negative effect on efficiency.

al., 2009; Bellemare, 2012), (ii) improves productivity and efficiency (Rao et al., 2009), and/or (iii) increases the portfolio of suppliers' assets (Michelson, 2013). This stream of research also emphasizes the importance of providing technical advice (extension services) and access to inputs (e.g., seeds, agrochemicals), and contextual elements such as the availability of infrastructure, proximity to markets, involvement of NGOs or donor-funded projects in the development of supply chains, or the fact that in developing countries the retail sector is still developing (Michelson, 2013).

Yet, while the spread of supermarkets and retail companies generally have a positive impact on participating smallholder farmers in developing regions, Barrett et al. (2012) note that only a small fraction of smallholders manage to access modern commercialization and dynamic markets while many other remain in the semi-subsistence system. Ebata and Hernández (2017) stress that commercialization by small-scale agricultural producers is often hindered by high transaction costs related to coordination failures between agents (whether private and/or public) and to regulatory requirements. In addition, many small-scale producers in developing countries lack appropriate managerial capacity and lack access to adequate production technology and infrastructure, preventing them from effectively accessing markets and commercialization.

In the case of Sub-Saharan Africa, Bjornlund et al. (2020) further point the importance of improving governance structures and market integration for a transition from low-producing, unprofitable agriculture to modern, efficient, and profitable systems. The authors similarly recognize the role of history in preventing the development of agro-processing and manufacturing industries (with African colonies having been used to source raw products for export to colonial powers where processing would occur thus favoring concentration of manufacturing and processing activities among a smaller number of countries) as well as geopolitical, financial, and trade issues that constrain African countries from introducing policies to adopt modern technologies and increase agricultural productivity.

Hence, conclusions drawn from participation in modern channels are typically presented with caution, and often recommend policies that include improved credit, extension services, and input delivery systems, which can help farmers to sustainably upgrade their production technology.

However, more research is necessary to better understand the implications of market concentration in contexts of increased market linkage and commercialization activities with the retail (supermarket) sector. As remarked by Swinnen (2020), with search and contracting problems, increased competition may complicate coordination and contracting since hold-up opportunities and/or transaction costs increase, which can apply both to developed and developing market conditions.[44] On this point, Macchiavello and Morjaria (2021), recently analyzed relational contracts between upstream farmers and downstream mills in the Rwanda coffee chain and show that additional competition by mills increases the likelihood of farmers defaulting on contracts, makes farmers worse off, and results in lower aggregate quantity of coffee supplied to mills.[45]

Lastly, the role of cooperatives in generating or countervailing market power has received some attention in the literature. Lee and Van Cayseele (2022), for instance, recently estimate firm-level markups and markup volatility to identify the market power of farmer and processor cooperatives in the Italian fruits and vegetable and dairy sectors. The period of analysis (2007-2014) is characterized by major price volatility in global agricultural and food markets that also allows to assess whether cooperatives could function as a management strategy against risk. The estimation results show a tradeoff in cooperatives' roles between obtaining market power and stability, i.e., cooperatives obtain stability in their markups at the expense of lower markup levels. Farmer cooperatives seem to place a higher importance on profit stability due to the inherent uncertainties that already exist in agricultural production. Processor cooperatives, instead, obtain more market power in the fruits and vegetable sector that appear to arise from the product differentiation strategy of these cooperatives, while processor cooperatives in the dairy sector obtain higher stability but their market power is lower.

[44] Mérel and Sexton (2017) observe that the length of processors' commitments (in the form of contracts) is shorter than the lifespan of the specialized sunk assets required by farmers to meet the processors' needs. This leads to the so-called holdup problem: anticipating that processors will exploit short-run input supply inelasticities (exacerbated by perishability and limited selling outlets), farmers underinvest in specialized resources relative to the social optimum.

[45] The authors, however, remark that the benefits of competition might be hampered by the presence of other market failures (e.g., imperfect input and financial markets) and point to the possibility of excessive entry when contracts are hard to enforce. In this case, a mill's efficiency requires well-functioning relationships with farmers in which the sale of coffee cherries at harvest is bundled together with the exchange of services before, during, and after harvest in both directions.

3.3 Downstream

Koppenberg and Hirsch (2021) study mark-up pricing behavior in the food retailing sector in the EU, specifically in Finland, France, Italy, Portugal, and Sweden, for the period between 2010 and 2018. The authors use two different mark-up identification methods (the stochastic frontier approach-SFA and the production function approach-PFA).[46] These countries were chosen based on data availability and the fact that their retail sectors exhibit different degrees of concentration. Their analysis indicates that the two methods lead to significantly different average mark-up levels, which provide differing assessments of the state of competition in the analyzed sectors. Accordingly, the authors encourage other researchers examining market power to discuss assumptions in greater depth and to be careful when submitting policy recommendations based on consumer welfare loss calculations stemming from markup estimates.

Bonanno et al. (2018) reviews the predictive capability of traditional models and tools to assess and measure market power in the agri-food sector and remarks the importance of thinking in terms of other paradigms, especially bargaining power rather than (or in addition to) market power. Similarly, in their review of pricing strategies among food retailers in developed countries, Hamilton et al. (2020) assess theoretical and empirical evidence for retail pricing and the vertical relationships that have emerged among retailers, food manufacturers, and farmers.[47] The study presents several examples of strategies to price above marginal cost and considers an emerging body of research that frames vertical relationships between suppliers and retailers in terms of bargaining power (for example, using the Nash bargaining model) instead of the traditional market power approach.[48] The authors remark that future research should consider new ways of thinking

[46] The authors chose the EU food retailing sector for the analysis since antitrust authorities have recurrently initiated investigations against food retailing companies in several member states, for example, the Czech Republic and Finland (OECD, 2014) or France (European Commission, 2019).

[47] The analysis of consumer behavior in multiproduct retail markets includes consumer search, habit formation, and reference pricing. The authors also discuss retail market outcomes for price discrimination, price fairness, and price obfuscation; and then turn to examine the relationships between retailers and food manufacturers through bargaining outcomes, market foreclosure, and slotting allowances, and discuss the resulting implications for retail-price pass-through.

[48] In the standard Nash bargaining model, the estimator of bargaining power is a function of agreement and disagreement payoffs, the latter being the payoffs earned by each player in the absence of an agreement. In satisfying the solution, this model assumes simultaneous and bilateral negotiations such that, in equilibrium, no party wants to renegotiate (Horn and Wolinsky, 1988). For instance, the solution of the Nash bargaining problem between retailers and manufacturers, assuming Bertrand rivalry in downstream retailers, yields a

about vertical relationships among farmers, distributors, manufacturers, and retailers, and more closely examine how market power is consolidated in an increasingly concentrated food system at each of the various points in the supply chain.

For example, in an application of the Nash bargaining model to assess vertical relationships between Chilean retailers and coffee manufacturers, Noton and Elberg (2013) challenge the view that large supermarket chains can extract most of the surplus generated across the value chain. During their period of analysis, the two retail chains included in the study captured more than 60% of the total supermarket sales in the country and 88% of the coffee sales at supermarkets.[49] Yet, the authors find that small coffee manufacturers obtain a sizeable fraction of the surplus, consistent with a strong bargaining power and despite their small market shares. In addition, in a context of a volatile surplus due to large swings in international coffee prices, manufacturers absorb most cost shocks, which could be due to their relative advantage, compared to retailers, in terms of inventory or hedging management. In this line, the authors suggest that more research is necessary to examine the relationship between cost absorption and inventory and/or hedging behavior in vertical channels under surplus volatility (as in bread-wheat, poultry-corn, chocolate-cacao, cooking oil-oilseeds value chains), exploring the sources of bargaining power with richer datasets in terms of the number and characteristics of bargainers.

More generally, advancing in this area of research could complement with the relatively recent findings in the analysis of strategies of large firms, such as supermarkets in food retail. Hausmann and Leibtag (2007) show that retail food prices fall when a Walmart store opens in a specific geographic location using US household data for the period 1998 to 2001.[50] Based also on data

single parameter that describes the share of the total margin that is appropriated by either the manufacturer or the retailer, depending on the relative bargaining strength of each party. Substitution and complementarity (i.e., the structure of demand) are key factors determining the payoffs and can have significant effects on estimated bargaining-power parameters, as shown by Richards et al. (2018a) using data on multi-category soft drink purchases among households in France.

[49] One supermarket chain was acquired by US-based Walmart, and the other had started an internationalization process to several other Latin American countries, including Argentina, Brazil, Colombia, and Peru.

[50] The study uses a customized subset of the ACNielsen Homescan scanner panel data for randomly selected households across the US. The authors further argue that Walmart supercenters have had the biggest impact on food retailing as they compete most closely with traditional supermarkets and offer many identical food items at an average price about 15%–25% lower than traditional supermarkets.

from US markets from late 1980s to late 1990s, Jia (2008) develop an empirical model showing that expansion of a large retailer could make unprofitable or unable to recover sunk costs for roughly 50% of discount stores in the same markets. These findings have encountered explanation in Smith and Thomassen (2012) and Rhodes (2015), who argue that product complementarity influences pricing strategies among retailers downstream. Internalizing cross-product pricing effects on the intra-retailer margin with product complementarity leads to lower retail prices as retailers have an incentive to drive volume rather than margins. As this food business works with small margins, reaching high volume of sales is essential; this similarly provides support to why supermarkets may enter into price wars to wipe out competitors in local markets or, alternatively, profile products for niche markets (e.g., gourmet foods; organics) or store "feeling" (including convenience of selling assortments as broad as possible of food and non-food items).[51] On the other hand, regarding inter-retailer strategies, Richards et al. (2018b) present evidence in the other direction showing that product complementarity is associated with anti-competitive effects and is a source of market power for retailers; the authors point out that previous evidence on single category purchases does not take into account that once customers have made the trip to the store, product complementarity could lead to softening competition and higher equilibrium prices relative to the case where customers purchase products with independent demands. Yet, Richards et al. (2018a) argue that none of these studies focused on vertical relationships between multi-product retailers and manufacturers. To incorporate this dimension, the authors develop an empirical model of bargaining that includes products from four different sub-categories in the soft-drink industry in France and show that product complementarity can lead to a higher retailer share of the total margin. This means that retailers can enhance their bargaining power, relative to manufacturers, by selling complementary products across categories. Retailers understand that manufacturers may need to offer a broad array of products across different categories to extend their company (brand) appeal;[52] hence, knowing the pressures faced by manufacturers, retailers can negotiate accordingly and are able to extract greater rents in the vertical channel. As brands expand across related categories, and even related channels, retailers can take advantage that manufacturers need to be omni-present to stay in consumers' minds. Manufacturers negotiate with

[51] The emergence of larger retail-store formats enhances the opportunity for retailers to generate rents from cross-category purchases through price discrimination (Hamilton et al., 2020).

[52] For instance, food processors may brand (or set some standard) for their own products and compete for market shares through such branding (alleged quality) in a way to enjoy higher margins for such products.

retailers' incentives in mind, so complementarity between products should imply more retailer bargaining power and lower manufacturer power, relative to the usual substitute-products situation.[53]

In the aforementioned research review of Sheldon (2017), there is evidence suggesting that US food retailing may already be undergoing further structural change in recent years, with traditional food retailers finding difficulties to follow a strategy of product variety expansion, given competitive pressure on their margins from big retailers and the increasing incentive to focus on a narrower range of high-quality fresh unpackaged foods (Watson, 2016), combined with the fact that online food retailing is expected to grow more rapidly over the next decade compared with traditional food retailing. On this matter, Hamilton et al. (2020) point out that retailers such as Walmart offer a wide range of in-store services, potentially increasing their opportunities to raise overall store margins through other mechanisms, like price obfuscation strategies (Piccione and Spiegler, 2012); the authors further remark that pricing complementarity strategies not only provide an alternative explanation for the rise of large retailers, but also help to explain increased investment in the food retailing industry (e.g., the entrance of Aldi into the US market and the purchase of Whole Foods by Amazon).[54]

In a broader assessment of macroeconomic implications of market power in the US, De Loecker et al. (2020) document the evolution of market power across all sectors of the economy using firm-level data for publicly traded firms over the period 1955-2016 and data from the US Census on manufacturing, wholesale, and retail.[55] The authors show that markups started to rise after the

[53] When products sold by one manufacturer are complements downstream, the disagreement profit, which is the amount earned if the parties fail to agree, is lower with complementarity than under strict substitutability. Lower disagreement profit implies a higher opportunity cost of agreeing. As a result, manufacturers are essentially keener to arrive at a negotiated solution, such that their bargaining power is lower (Richards et al. (2018a).

[54] Hamilton et al. (2020) also point out that the ability to search more efficiently for desired product attributes in online markets can sharpen inter-retailer product differentiation and reduce the elasticity of demand for foods sold online, thereby raising retail margins.

[55] The study is based on Compustat firm-level financial variables of all US publicly listed companies active at any point during 1950-2016. Census data for manufacturing (NAICS codes 31-32-33), wholesale (NAICS code 42), and retail (NAICS codes 44-45) is used to perform robustness checks and verify the extent of selection bias in the sample of publicly traded firms. The authors estimate that these three sectors account for roughly 20% of the US Gross Domestic Product (GDP). The figures for manufacturing and wholesale using Census data are in line with the main results using data from publicly traded firms; but in

1980s, from 21% above marginal cost to 61% in 2016, and the increase is mainly driven by sharp increases in the upper tail of the markup distribution (i.e., in the upper percentiles). They also find a reallocation of market shares from low- to high-markup firms within industries as well as an increase in the average profit rate from 1% to 8%. These estimates are based on a method developed in De Loecker and Warzynski (2012) that uses information from firms' financial statements and does not require any assumptions on demand and how firms compete.[56] As data requirements become more accessible, this method could be more suitable for analyzing specific industries across the agri-food sector in other countries, compared to more standard approaches using structural methods.

In developing countries, Atkin and Donaldson (2015) generate estimates of the relative scale of intra-national trade frictions and show their implications for market power. Using data from Ethiopia, Nigeria, and the US, the study analyzes barcode-level price data for many processed food items (that permit to control for unobservable product quality differences) and identify the exact point of origin of each product matched with observed consumer retail prices in spatially varied markets (to account for the distance each product travelled to where its price was observed). The authors find that the effect of distance on trade costs is 4-5 times larger in Africa than in the US, which permits to infer the extent of local market power exertion. On this matter, Barrett et al. (2021) indicate that these local trade frictions lead to intermediary market power such that traders capture most of the gains from reduced costs of imports that result from lower international trade barriers.

Finally, as part of the nascent experimental literature to learn about market competition, Busso and Galiani (2019) examine the impact of randomly induced entry of small retail shops on prices and quality in the Dominican Republic. By experimentally varying the number of new stores authorized to accept debit card payments of a conditional cash transfer program, the study shows that incumbent stores reduced prices from 2% to 6% and exhibit a statistically significant

the retail sector, the pattern of markups obtained is flat or slightly increasing until 2002, and for 2012 show a sharp increase that is not observed for publicly traded firms.

[56] In this method (PFA), markups are obtained by exploiting cost minimization of a variable input of production, which requires defining the production function (i.e., technology) to obtain the output elasticity of (at least) this variable input of production.

improvement in customer-reported service quality, with greater effects in places with more new entrants. The authors argue that competition seems to have driven part of the customers away from incumbent retailers.

Overall, most reviews of market power in agri-food value chains have mainly focused on midstream and downstream markets in developed economies, where there is more data availability, and do not find strong evidence of market power exertion, especially buyer power from food processing firms. Few studies find evidence of economically significant levels of market power and/or price distortions. The evidence regarding asymmetric price transmission and its relationship with buyer concentration is similarly mixed and varies across sectors and periods. In developing countries, the literature is scarcer but shows the importance of contextual elements such as remoteness, financial liquidity constraints, credibility, reputation issues, and high transaction costs in conferring considerable market power, where intermediaries can take larger rents from consumers and farmers. Similarly, the emerging experimental evidence in developing countries on market competition and performance is mixed although it is not generalizable as it has largely focused on establishing the relevance of a specific market mechanism or characteristic in the value chain under study; e.g., the aforementioned work by Busso and Galiani (2019) showing that randomized entry in grocery stores in Dominican Republic reduces prices and improves quality; randomized subsidies to cocoa traders in Sierra Leone revealing a relatively competitive intermediary (traders) segment, with a low degree of differentiation and a large market size, but showing substantially less competition downstream the value chain (e.g., wholesalers, exporters), as shown by Casaburi and Reed (2022); and randomized cost shocks and subsidies to maize traders in Kenya showing a high degree of market power and rent capture among intermediaries while exogenously induced firm entry has negligible effects on prices, as presented by Bergquist and Dinerstein (2020). See Reed (2022) for additional discussion on the possibilities that randomized studies and experimental design can offer to research questions related to market competition, welfare, and policy. More generally, and borrowing a term used by Macchiavello et al. (2022), the literature on food value chain transformation have not sufficiently "cross-pollinated" to empirical industrial organization. The authors argue that applying these advanced methods to food value chains in developing countries is now relevant because of the transformation (including favoring

concentration) that has occurred and possibly due to the increasing availability of data from surveys of farms, processors, and wholesalers, and scanner data from some retailers.

Upstream, high levels of concentration in fertilizer and seed markets, combined with elevated levels of multimarket contact in those industries (where big multinational firms compete with the same rivals in multiple markets) are a matter of concern in terms of the effects that reduced competition or coordinated actions could have on fertilizer uptake or, more generally, on agricultural productivity. Record high fertilizer prices over the past and recent major events, such as the Russian aggression against Ukraine, further rise these fears, including global food security concerns, in a context where supply disruptions and export restrictions or bans to one of the few major worldwide producers can provoke immediate impacts on global fertilizer availability and accessibility.

In the same vein, as argued by O'Connor, (2021), the global pandemic has spread preoccupations derived from disruptions and shortages in agri-food supply chains and the increasing presence of larger and powerful downstream buyers across the globe. While achieving efficiency is a desired objective from both an allocation of resources perspective and for obvious reasons regarding its capacity to achieve low prices and welfare enhancing features from the perspective of consumers, there is an increasing need to further understand the implications of concentration among a few powerful buyers in the agri-food chain, at the expense of farmers, other producers, and workers.

In addition, the relatively few companies purchasing bulk agricultural commodities for international trade (pointed in Section 2.3) merits some attention in a context where global wheat prices have been recently increasing and fluctuating substantially (FAS-USDA, 2022), after market reactions to announcements about the Indian wheat export ban and ongoing negotiations regarding Ukraine's ability to ship, while Russia is still expected to be the main wheat exporter in 2022-2023 (despite economic sanctions and export taxes). Murphy et al. (2012) note that the few major trading companies act as midstream buyers who purchase high volumes and have leverage in terms of setting prices, particularly with farmers with whom they contract directly, as well as with grain elevators to which farmers in industrialized production systems deliver their grain. The authors further remark the role of the four major corporations (ABCD firms) in the so called

"financialization" of commodity markets and on potential speculation and food price volatility, which is worth exploring.[57]

As more disaggregated data can be accessed or compiled (including detailed transaction data), new approaches and methodologies are being developed to better understand the complex relationship between market concentration, conduct, and performance at various points in the agri-food chain among input suppliers, farmers, distributors, food manufacturers, and retailers. These include an emerging body of theoretical and empirical research that frames vertical relationships between suppliers and retailers in terms of bargaining power instead of the traditional market power approach; recent developments in markup estimation methods that discuss assumptions in greater depth and recommends being careful when submitting policy recommendations based on consumer welfare loss calculations; and novel approaches based on experimental designs that represent new streams of research on market concentration and power and their welfare implications, particularly in less developed countries where data are typically collected from the field (as data availability is very limited) in more controlled settings. More research is also necessary to assess the impact of UTPs along the agri-food chain, i.e., not only on farmers but on other suppliers down the chain and consumers. Efficiency and rent distributional implications of some practices are similarly still not clearly understood in the literature. Although beyond the scope this study, studies analyzing the impact of concentration on conduct and performance in the food service industry (e.g., restaurants, fast-food chains) could be another interesting avenue for future research as the literature on this topic is very scarce.

[57] See Cheng and Xiong (2014) for an extensive review of the impact of financialization on commodity prices. Robles et al. (2009) also examined the role of speculation on agricultural commodity prices during the food price crisis of 2007-2008 and show that speculative activities might have been influential.

4. Implications of market concentration for food security and nutrition and environmental sustainability

This section assesses the potential implications of market concentration on food security and nutrition and environmental sustainability. In the case of food security and nutrition, the analysis pays special attention to access to healthy diets and reviews the available evidence both among smallholder farmer households and urban consumers considering the changing trends in commercialization channels and the food retail sector, particularly with the rapid expansion of supermarkets that have increased vertical integration and coordination favoring concentration along the chain.[58] In the context of environmental sustainability, the analysis focuses on reviewing the existing literature on the implications of concentration and/or vertical integration or participation in modern commercialization channels across the agri-food chain on environmental issues, including food loss and waste (FLW).

4.1 Implications for food security and nutrition

As pointed out earlier, the modernization of commercialization channels over the past decades has promoted the establishment of supply agreements with small farmers, with the potential to improve their welfare (e.g., Reardon et al., 2009; Rao et al., 2012). Several studies have examined the impact of participation in supermarkets' value chains on income, consumption expenditure, labor market insertion, and agricultural productivity (e.g., Miyata et al., 2009, Neven et al., 2009; Rao and Qaim, 2011; Bellemare, 2012; Michelson, 2013; Rao and Qaim, 2013; Andersson, et al. 2015; Mossie et al. 2021). Most of these studies conclude that supermarkets can contribute to rural economic growth, increased incomes, and modernization of the small farm sector. However, the evidence is scant regarding changes in dietary habits or nutritional status among smallholder households associated with engagement in supermarket chains (Gomez and Rickets, 2013; Popkin, 2014; Chege et al., 2015).

[58] Following Lee et al. (2013), a healthy diet can be defined as a diet that provides recommended amounts of foods, nutrients, and other food components, within estimated energy requirements, to promote normal growth and development in children, reduce risk of obesity and noncommunicable diseases, and promote optimum well-being at all ages, consistent with national dietary guidelines/recommendations.

Most of the recent research in developing countries about the impact of small farmers participation in modern value chains on food access and consumption has focused on African and South Asia with mixed results. Carletto et al. (2017) use data from Tanzania, Uganda, and Malawi and find little evidence of an association between increased commercialization and improved nutrition among farm households based on children's anthropometric measures, household per capita food expenditure, and household per capita caloric consumption. In Tanzania, Herrmann et al. (2018) investigate the impact of market linkages on agricultural income and food security. Even though farmers who have access to markets exhibit higher crop yields and receive better prices, there are no significant differences in household food security measured through weekly total per capita food consumption, household dietary diversity, or a household food insecurity access scale. Mishra et al. (2018) assess the impact of contract farming on smallholders in India and, among other results, find that its adoption increases food security measured through a higher share of food expenditures on total expenditures. Debela et al. (2022), show that the impact of contract farming in palm oil on smallholder nutrition in Ghana depends on the type of contract employed. Resource-providing contracts that include in-kind credits and technical assistance have larger effects than marketing contracts, which can even have negative effects in some cases.

Literature that specifically address the relationship between supermarket contracts and smallholder farmer's nutrition is more conclusive, but equally mainly focused on African countries. For example, Chege et al. (2015), compare nutritional indicators between farm households with and without supermarket contracts in Kenya and report that participation in supermarket channels can increase household income and diversify crop production, thereby improving household nutrition. Ochieng (2017), also using data from Kenya, analyzes the situation of vegetable producers in Kenya and finds that having contracts with supermarkets increases household income and dietary diversity, as well as calories consumed and zinc intake. Onyeneke, et al. (2020) examine the case of Nigerian poultry producers and find that the availability of modern food retail markets, including supermarkets as well as fast food firms, hotels, and convenience stores, correlates with better quality diets. Factors contributing to healthier diets include an increase in dietary diversity, a growth in poultry consumption and the production of vegetables, and changes in household gender roles.

In sum, the association between participation in modern commercialization channels, especially supermarket channels, and access to better diets among small farmers appears to be positive, but certainly the literature is still relatively limited to derive more generalized conclusions. The impacts may be context specific and could be affected by a variety of factors such as contract terms and farmers' conditions. More research is required in this area to explore these factors. In the same vein, it is important to extend the research to other countries or regions, as the effects may vary across areas considering the major role of geographic location and accessibility on effectively integrating small farmers into global supply chains. In addition, future work should attempt to capture more detailed data, including macro and micronutrient data, to assess impacts beyond consumption of specific food groups and dietary diversity.

On the other hand, the rapid growth of urban populations worldwide has contributed at the same time to a significant transformation of food retail systems to attend the increasing demand for a wide range of food in fast-growing cities, including many developing countries. Part of the transformation has been led by the wide expansion of supermarkets in urban and peri-urban areas (i.e., the "supermarket revolution"), which has changed the nature of distribution networks and supply chains while seeking to satisfy consumer food demand for year-round in a timely and efficient manner (Reardon et al., 2003).[59] Supermarkets have modern procurement systems, such as buying in bulk to lower costs and improve efficiency (i.e., offering competitive prices), and impose private standards to raise quality (Reardon and Timmer, 2007), but their diversification of food availability, including both healthy fresh foods rich in essential nutrients and less healthy energy-dense and nutrient-poor foods (usually processed), can also have important implications for the health and nutrition of the population, particularly the poor.

In this context, several studies have reviewed how changes in the food retailing system due to the increasing presence of supermarkets is correlated with variations in urban consumption and dietary

[59] While supermarkets started to proliferate in developed countries (such as the United States and Canada) since the mid of the twentieth century, their expansion in developed countries started in the 1990s and occurred in four "waves": a first wave in South America, East Asia (excluding China), and South Africa in the early 1990s; a second wave in Central America, Mexico, and Southeast Asia in the mid 1990s; a third wave in China, India, Vietnam, and parts of Africa in the late 1990s to early 2000s; and a fourth wave in other parts of Africa and South Asia in the mid to late 2000s (Minten and Reardon, 2008).

patterns. Hawkes (2008) performs a wide-ranging literature review and indicates that supermarkets can make a more diverse diet available and accessible to more people but can also promote the consumption of energy-dense and nutrient-poor, highly processed foods among poor populations; the author concludes that supermarkets overall encourage consumers to eat more, despite the type of food. Monteiro et al. (2013) shows that ultra-processed products (i.e., energy-dense, fatty, sugary or salty and generally obesogenic foods) are increasingly dominant in high- and middle-income countries mainly driven by transnational food manufacturing, retailing, and fast-food service corporations. Popkin (2014) indicates that the rapid growth of the retail sector in middle- and low-income countries is contributing for processed and packaged food to rapidly reach food insecure and overweight populations, which can pose major challenges to the health of the poor. Similarly, Qaim (2017) points out that although there is still an important presence of wet markets and traditional grocery outlets in several developing countries, the growing role of supermarkets and processed foods can contribute to overweight and obesity among consumers. Reardon et al. (2021) argue that the increase in stunting, overweight, and obesity in Africa is linked to the increase in the consumption of ultra-processed foods, which is driven by the expansion of the food processing sector and massive investment by large private enterprises. In their recent review of the evidence of dietary transition and food system transformation during economic development, Masters et al. (2022) find that supermarkets have had a rather negative impact on nutrition outcomes, mainly through their association with increased consumption of ultra-processed foods with harmful attributes.

Concrete evidence, however, on the direct effect of supermarkets on consumer nutritional status using detailed micro data is still mixed and context specific. In the US, for example, Drewnowski et al. (2012) find that the risk of obesity is not associated with physical proximity to a supermarket, but it is inversely associated with supermarkets offering higher priced products, concluding that improving access to health foods is beyond improving access to supermarkets. Lear et al. (2013) find that the food basket price of supermarkets is inversely correlated with the body mass index (BMI) of their shoppers. Rogus et al. (2018), in turn, show that the opening of a supermarket in a low-access neighborhood affected local food purchasing and consumption behavior: while the purchase of both healthy and unhealthy foods increased, the consumption of healthy items (water, fruits, vegetables) also increased and of unhealthy items decreased (soft drinks, salty snacks,

pastries). Li et al. (2021) recently performed a systematic review and meta-analysis of 35 studies (most of them in the US and Canada) analyzing access to grocery stores and childhood obesity and find a rather weak relationship, while Zhou et al. (2021) systematic review across 24 studies (21 in the US) reveals a mixed relationship between access to supermarkets and weight-related outcomes.[60]

In developing countries, the literature is similarly not conclusive. Minten and Reardon (2008), using data from Madagascar, find that supermarkets sell higher quality food than traditional markets, but they charge higher prices, even after controlling for quality. Tessier et al. (2008) find that regular users of supermarkets in Tunisia have a slightly improved diet quality. Asfaw (2008) examine the case of Guatemala and show that supermarket purchases increase the share of highly and partially processed foods at the expense of staple foods and are also positively associated with individuals' BMI. Rischke et al. (2015) find that supermarkets in Kenya promote the consumption of processed food, relative to unprocessed food, and increase daily calorie availability. Kimenju et al. (2015) indicate that supermarkets may increase the BMI and probability of overweight among adult consumers in Kenya, but no effects are observed for the BMI among children and adolescents combined with a positive impact on their height-for-age. Umberger et al. (2015) do not find a significant relationship between shopping in supermarkets and nutrition outcomes among adults in Indonesia. Demmler et al. (2018) show that shopping in supermarkets in Kenya contributes to higher consumption of processed and highly processed foods and lower consumption of unprocessed foods, thereby significantly increasing the BMI of the population. In contrast, Debela et al. (2020) find positive effects of supermarket purchases on child nutrition in Kenya.

Overall, the relationship between supermarkets' presence and consumer health and nutrition in urban areas is still not well understood. Part of this ambiguity could be explained by the different driving forces that affect consumer food choices (Ruel et al., 2020), including market competition that has not been encompassed in previous analyses of the linkages between supermarkets and dietary patterns, probably due to the lack of detailed data. While supermarkets may charge, on average, higher or lower food prices or offer a higher or lower share of high-quality foods than

[60] Adam and Jensen (2016) find, however, that obesity related interventions at retail grocery stores and supermarkets are effective in increasing the purchase of healthy foods.

traditional markets, little has been said about how the level and type of competition they face in specific markets may accentuate (or weaken) these differences, ultimately affecting the dietary habits and health and nutrition of the population, especially the urban poor. The pricing of healthy, nutrient-rich fresh foods versus less healthy processed foods can certainly depend on the level of competition in each area of operation and constitutes an important avenue of future research.[61]

4.2 Implications for environmental sustainability

There are important environmental sustainability concerns in the agri-food industry.[62] According to Tubiello et al. (2021), food systems are responsible for one third of the total global anthropogenic (human-caused) greenhouse gas emissions, where three quarters of these emissions are generated either within the farm gate on in pre- and post-production activities, such as manufacturing, transport, processing, and waste disposal. Crippa et al. (2021) indicate that the largest contribution to greenhouse gas emissions comes from agriculture and land use/land-use change activities. The overuse of chemicals and fertilizers and pesticides has brought environmental problems such as water pollution, biodiversity loss, and nitrous oxide emissions (Eicher and Staatz, 1998). In food retail, the primary energy resources are gas and electricity due to business operations, shopping activities, and equipment used for food preparation, storage, and presentation, which leads to a significant emission of carbon dioxide (Lukic, 2016). In supermarkets, for example, refrigeration, lighting, and heating/air conditioning systems are managed with a high electricity consumption, which has a negative environmental impact (Baldwin, 2011; Beshr et al. 2015). Among the reasons why retailers are hesitant to adopt energy-saving technologies is the enormous cost of implementation along with a lack of internal financial resources available to support these changes (Dixon-O'Mara and Ryan, 2017). Food retail operations also contribute to air and water pollution. Most supermarkets discharge grease and food waste directly into municipal sanitary sewers, and vertically integrated food retailers manage warehousing and distribution functions, concentrating air pollutants generated during the production process as well as emissions from trucks in these distribution centers (Davies and

[61] A standard textbook model would predict higher prices with market power, but the impact on nutrition is not clear as higher prices for highly processed or junk food would be good and the opposite for higher fruits and vegetable prices.

[62] Environmental sustainability refers to the preservation of natural resources by not exceeding the local environment capacity to absorb emissions (Goodland, 1996).

Konisky, 2000; Renko et al., 2010). The increase in concentration in the agri-food system suggests that ecological degradation may be influenced by a small group of major market actors in food and agriculture (Shelke et al., 2011; Hendrickson et al., 2020). Yet, there is little evidence that specifically analyzes the relationship between market concentration and environmental sustainability.

Some of the literature has focused on the upstream segment of the agri-food chain, particularly in the seeds market, and the evidence is mixed. According to the OECD (2018a), researchers have noted that a high degree of market concentration in the seeds market may not necessarily be harmful. Competition among a few large players can in fact promote innovation that contributes to environmental sustainability, productivity, and resilience. However, non-horizontal mergers (i.e., vertical integrations) are not necessarily harmless as they could be used to exclude competitors from accessing important markets or resources. Solberg and Breian (2015), for example, find that consolidation of seed enterprises and vertical integration caused the Nordic countries to concentrate on a few crops and abandon others for nearly fifty years. The shift away from regional and locally produced products decreases diversity, which is detrimental to environmental sustainability. Mustonen-Park (2018) performs a wide-ranging literature review and points that outside of the United States, seed markets are very restricted due to lack of research and development, contributing to a decline of seed varieties.

Several studies have also examined the impact of the food industry on environmental sustainability using the Life Cycle Assessment (LCA) method. This methodology involves incorporating all the material and energy flows associated with a product during its entire life cycle to estimate the environmental impact associated with a food value chain. This kind of research can be useful for identifying which parts of the chain may have an impact on the environment. Yet, since most of the studies are focused on a particular food supply chain and rely on a series of assumptions according to a forthcoming work on the topic by the OECD, they typically lack external validity. Cerutti et. al (2013), Garofalo et al. (2016), Poore and Nemecek (2018), and Shen et al. (2021) are some examples. Most of this literature do not explicitly account for market concentration or competitive practices in these industries but generally find that land use and agricultural production account for most of the total environmental footprint. Keyes et al. (2013)

is one of the few studies that addresses vertical integration through the analysis of environmental performance and opportunities for improvement in apple supply chains in Canada using the life cycle assessment approach. The authors compare the environmental impacts between standard orchard production and cradle-to-retail chains (namely vertically integrated chains) and find that the latter have most adverse effects on electricity for long-term storage and long-distance truck delivery.

Regarding the literature on FLW, there is some discussion of the connection between market concentration and environmental sustainability. FAO (2019) defines FLW as the decrease in quantity or quality of food along the food supply chain.[63] In the food supply chain, losses occur during the production, postharvest, storage, transport, and processing stages, whereas food waste is the food discarded in the food retail sector, food service sector, and households (Parfitt et al., 2010; UNEP, 2021). Kummu et al. (2012) estimate that around one quarter of the water resources, cropland, and fertilizers used to produce food are lost due to FLW across the global food supply chain. A study on food waste by European Communities (2011) remarks that environmental sustainability is affected due to transportation and shipping towards landfills combined with upstream production, resources usage, and life cycle processes that could have been avoided. Feedback (2017) argues that food waste is a symptom of structural problems that relate to a power imbalance and lack of incentives to minimize food waste. Power imbalances can result in a decline in innovation and investment that will affect small and medium-sized food businesses in the long term, deriving in higher food prices and fewer choices for consumers. However, there are some authors who argue that waste is part of any optimal production process, and that food waste can be used for other non-food purposes, such as animal feed, fertilizer, and biomass to produce other goods. Under this premise, food waste would be defined only as produce that ends up in landfills (Bellemare et al., 2017).

In this context, there are only few studies examine FWL in specific food value chains and their links with market concentration and/or vertical integration. Some of these focus on developed countries and find that most of the losses stem from the power imbalance in the retail side of the

[63] Quantitative losses refer to food that exits the food supply chain, while qualitative losses refer to the decrease in food attributes that reduces its value for intended use (Cattaneo et al., 2021)

chain. Devin and Richardson (2018), for example, assesses how retailers in the fresh fruit supply chain in Australia contribute significantly to food waste by interviewing different actors along the chain, including retailers and producers. Since the bargaining power of retailers is high, they can pass food waste responsibility upward the chain to growers by offering lower prices after delivery and setting strict standards regarding the cosmetic appearance of food that leads to discard suitable food. Ghosh and Erickson (2019) use five-year company data for a medium-sized premium bread manufacturer and supplier in Sweden to examine how take-back agreements can be used by retailers to exert coercive control over suppliers in highly concentrated markets. In these contracts, the retailer is only required to pay the supplier for the quantity purchased but not for the quantity ordered. As a result, larger downstream players can negotiate better contracts with producers and reject viable products that end up being thrown away. Herzberg (2022) examines fresh fruit and vegetable supply chains in Germany based on multiple interviews with stakeholders. The author notes that the industry exhibits an upward trend of concentration and consolidation that are associated with short-notice cancellations, order changes, and sudden changes in quality requirements that contribute to food losses and waste.

Studies in developing countries, where market concentration and vertical integration are not that high, present mixed evidence regarding how market concentration and/or participation in modern commercialization channels influence FWL. Minten et al. (2020), for instance, explore postharvest losses (PHL) experienced by teff milk and perishable liquid milk in rural and urban areas of Ethiopia. The authors analyze PHL at all levels of the chain and conclude that modern retailers generate lower PHL than traditional retailers. More specifically, modern retailers maintain higher quality standards in the procurement process, provide better packaging and protection systems, and provide refrigeration, storage, and sales facilities that offer better quality. However, the authors argue that the stricter requirements by modern retail could also contribute to larger PHL upstream. Chanboud and Moustier (2020), in turn, examine FLW in the tomato supply chain (from production to retail), comparing the amount generated by supermarkets and non-supermarket channels in Colombia. The authors do not find significant differences in the resulting FLW between both commercialization channels.

All in all, the links between market concentration and environmental sustainability can be studied from different perspectives as vertical and horizontal integrations that favor concentration may occur both upstream and downstream the food value chain, which can result in varying competitive practices and environmental consequences. Yet, the current evidence is highly context specific as it pertains to specific market segments, supply chains, or regions.[64] In this sense, there is an important research gap that could be fulfilled by studying potential environmental effects across different value chains and market segments that are important for the food industry, as well as on the efficient use of resources such as water, land, and energy. The scarce literature in developing regions is also evident, where the lack of concentration and/or vertical integration could alternatively be a cause of food waste as smallholder farmers typically do not have the incentives or means to adopt food loss preventive practices, while downstream coordination problems with small-scale operating agents, who additionally lack of sufficient storage, transportation, and processing capacities, could favor food losses.

[64] Related to this matter, Barrett et al. (2021) remark that firms continuously search for new markets, more efficient management practices, inputs of higher quality, and new ways to differentiate their products in order to generate new profit sources as their past innovations diffuse to competitors. A study on sustainability and competition by the OECD (2020) points out, in turn, that the answer to the well-known Schumpeter-Arrow debate regarding whether monopoly or competition leads to more innovation, and in particular innovation in sustainability, can be better assessed with concrete situations.

5. Concluding remarks and the way forward

This study attempted to provide a comprehensive assessment of recent trends in market concentration in the agri-food industry and on how and to what extent concentration could affect market conduct and performance of food systems, as well as implications for food security and nutrition and environmental sustainability.

Regarding the current state of market concentration in the agri-food industry, the upstream segment of the chain is composed of highly concentrated industries, including fertilizers, agrochemicals, and seeds, which appear to be in a consolidation path with important global market players. Markets midstream the chain, particularly food manufacturing and processing, as well as downstream, especially supermarket retailing, similarly exhibit moderate to high levels of concentration that have either increased or remained stable in recent years across several countries. Grain commodity trade is also highly concentrated. Still, important data gaps remain across industries and regions that prevent a more comprehensive picture of market structure (concentration) in agri-food systems, including difficulties in accessing proprietary market and scientific data and market share data at more disaggregated levels, as well as analyses that are typically geographically narrowed. In addition, there are data aggregation challenges and complications, including the use of different variables for analysis (e.g., shares based on volume versus sales) or defining the relevant markets across segments. These shortcomings point to the necessity of devoting more efforts on data access, compilation, and processing.

Market concentration and consolidation along the chain over the past years have been largely led by mergers and acquisitions combined with the transformation of agri-food chains, including the expansion of supermarket retailing worldwide. While these increasing horizontal and vertical integrations can be associated with higher efficiencies (particularly through economies of scale and better coordination), they could also result in market power exertion, tacit collusion, and other anticompetitive practices in the absence of these efficiencies and other offsetting factors. Recent events, including the global pandemic and the Russian aggression against Ukraine, with disruptions in agri-food chains and record high (input) prices, have further raised these concerns. Yet, the relationship between concentration and market power exertion is multifaceted and the

evidence supporting market power abuse or anticompetitive behavior is not generally obvious and may be context specific. Concentration alone is not sufficient to exert market power or to effectively coordinate strategies among few large market players as this also depends on other market characteristics and factors, including the type and nature of competition. Deriving conclusive evidence regarding market power exertion is further challenging due to lack of comprehensive and detailed data.

Most reviews of market power in the agri-food industry have mainly focused on midstream and downstream markets in developed economies, where there is more data availability, and do not find strong evidence of market power exertion, particularly buyer power from food processing firms. The evidence on asymmetric price transmission and its relationship with buyer concentration is similarly not conclusive. In developing regions, the literature shows the importance of contextual factors such as remoteness, financial liquidity constraints, credibility, and reputation issues in conferring considerable market power; high transaction costs (search, storage, contracting costs) can also sharply limit competition as well as intra-national trade frictions. In these contexts, intermediaries can take large surpluses in detriment of consumers and farmers. Upstream, high levels of concentration in input markets, combined with elevated levels of multimarket contact in those industries, are a matter of further investigation in terms of the effects that reduced competition or coordinated actions could have on agricultural productivity. Additionally, more research is required to assess the impact of unfair trading practices (UTPs) along the chain (not only on farmers), while efficiency and rent distributional implications of some practices are still not fully clear.

New approaches and methodologies combined with access to more disaggregated data can be helpful for an improved understanding of the complex relationship between market concentration, conduct, and performance at various points in the agri-food chain and better inform eventual policy decisions. Some of these new approaches include an emerging strand of research that frames vertical relationships between suppliers and retailers in terms of bargaining power instead of the traditional market power approach; recent developments in markup estimation methods; and novel experimental approaches on market concentration and power and their welfare implications, particularly in less developed countries, although the results may not be generalizable. In

developing countries, as more data (including scanner data) become available, the implications of the transformation of food value chains (including favoring concentration) on market performance could also be studied relying on advanced empirical industrial organization methods that have been widely used in developed economies.

On the implications of market concentration on food security and nutrition, the association between participation in modern commercialization channels, especially supermarket channels, and access to better diets among small farmers seems to be positive, but the literature is still relatively limited to derive more generalized conclusions. The impacts could be affected by a variety of factors, such as contract terms and farmers' conditions, and more research is required to explore these factors and extend the research to other regions (beyond Africa and South Asia). Additionally, future studies should attempt to capture more detailed data, such as macro and micronutrient data, to evaluate effects beyond consumption of specific food groups and dietary diversity. Future research about this subject could explore some of the following specific questions: *Does participation in modern commercialization channels, especially supermarket channels, promote access to better and healthier diets to all participating farm households or are these impacts heterogenous or specific to particular groups? Do changes in dietary patterns hold in the medium and long term? What are the impacts on health and nutritional outcomes among household members, especially women and children? Do the effects observed in Africa or South Asia replicate in other developing regions? Do market conditions affect the contractual arrangements of smallholders participating in modern marketing channels and thereby their food access and diet quality?* These questions can help to better understand the implications of participating in modern commercialization channels on farm household health and nutrition and aid in the design of policies that can enhance the potential benefits of smallholders' participation in modern integrated markets.

In a similar vein, the relationship between supermarkets' presence and consumer health and nutrition is still not well understood. This could be explained by the different factors that influence consumer food choices, including market competition that has not been accounted for in previous analyses of the linkages between supermarkets and dietary patterns, probably due to data restrictions. Food prices and quality may, on average, be higher or lower in supermarkets compared

to traditional markets, but these differences may be aggravated or lessen depending on the degree of competition faced by supermarkets. More important, the pricing of healthy, nutrient-rich fresh foods versus less healthy processed foods may also depend on the level of competition and can have important implications for the health and nutrition of the population, especially the urban poor. Specific questions that could be addressed in future work include: *Do the price differentials between the set of healthy and less healthy foods vary with the level of competition faced by supermarkets? Are supermarkets more likely to change their pricing behavior when they directly compete with other supermarket chains than when they compete with traditional markets? How do changing market conditions and consequent varying relative pricing behavior of supermarkets affect consumer food choices and the health and nutrition of the population, especially the poor? How do changing market conditions affect non-price competition in terms of product quality and information, including labeling and stop signs, and how can public policies contribute to influence those decisions?* This type of analysis will allow to better inform how institutional arrangements and regulatory framework governing market activity in the retail sector could be modified to improve market performance (if applicable) and promote the consumption of healthier foods, particularly among vulnerable populations.

On the implications of market concentration on environmental sustainability, the literature on the links between concentration and environmental sustainability is highly context specific as it pertains to particular market segments, supply chains, or regions. In the seeds sector, for example, the evidence is mixed. Similarly, the literature on food loss and waste (FLW) points out that food waste could be a symptom of structural problems that relate to power imbalances and lack of incentives to minimize food waste. Available studies focusing on developed countries and specific food value chains argue that most of the losses stem from the power imbalance in the retail side of the chain. Certainly, in developing countries the lack of concentration and/or vertical integration could also be a cause of food waste as smallholders generally do not have the incentives or resources to implement food loss preventive practices, while downstream coordination difficulties with small-scale operating agents, who further have limited storage, transportation, and processing capacities, could contribute to food losses; this hypothesis, however, has not been much explored in the literature. Some research questions that may be interesting to further explore in the future include: *How is concentration upstream and downstream the agri-food chain affecting the*

environmental sustainability of two key agricultural resources such as water and land? Are more concentrated markets being less or more efficient in energy use with more advanced processing, cooling, packaging, and other energy-efficient practices? Is market concentration along the agri-food chain favoring specific competitive behavior and practices that, for example, hinder technology development and research or promote FWL? Is the extent of the situation on this regard different in developed versus developing countries?

In sum, the relationship between market concentration, conduct, and performance should be regarded as complex where the occurrence of mark-up pricing, unfair trading practices, collusion, crowding out of small-scale businesses, lower access to healthy diets, less innovation, and more (or less) food waste may be context-specific and influenced by factors other than concentration. As pointed above, several key data and research gaps remain to better understand these relationships and derive more generalized conclusions.

An action that could be implemented to alleviate part of the data and research gaps could be to expand competition authorities' capabilities to perform more in-depth market studies in specific industries or sectors along the agri-food value chain and encourage the disclosure of more detailed (and frequent) data. More important, it is key to invest in stronger national and multinational competition authorities and encourage more coordination among them to facilitate the convergence and effective enforcement of antitrust laws at the local, regional, and global level, and ensure that regulations and other policies do not accidentally create barriers to entry, restrain competition, or restrict trade between countries. The International Competition Network (ICN) is an interesting initiative on this regard as it is a global body devoted exclusively to competition law enforcement and its members represent national and multinational competition authorities. Yet, it is equally important to keep in mind that guaranteeing competition among agri-food markets will not solve poverty, food insecurity and malnutrition, and environmental issues, such that other, more targeted policies are almost certainly needed.

Similarly, with the wide use of new information technologies, the development of easily accessible virtual platforms (whether through local, regional, or global initiatives) could also contribute to increase market transparency and efficiency across different agri-food industries. These platforms

could report relevant market data, promote business (trade) opportunities and access to new markets, or even permit to submit complaints about potential regulatory violations or unfair trading practices.

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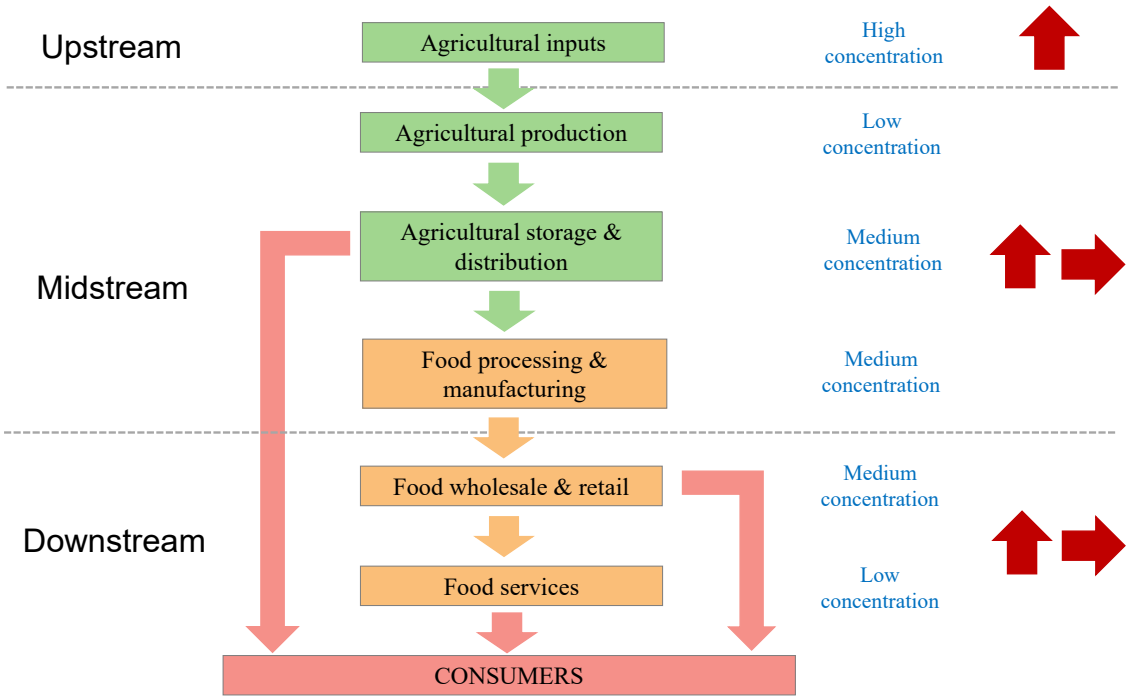
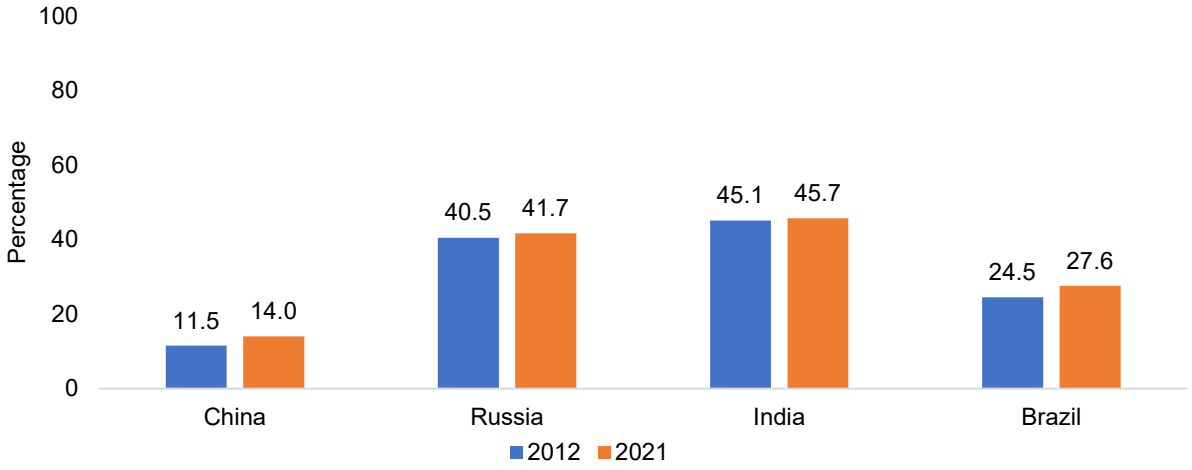
Figure 1.1. The agri-food industry



Note: The arrows on the right-hand-side of the figure depict recent concentration trends along the different segments of the agri-food industry: a single arrow pointing upwards implies increasing concentration over the past years, while an arrow pointing upwards and another pointing to the right implies increasing concentration in some segments and stable concentration in others.

Source: Authors' own elaboration.

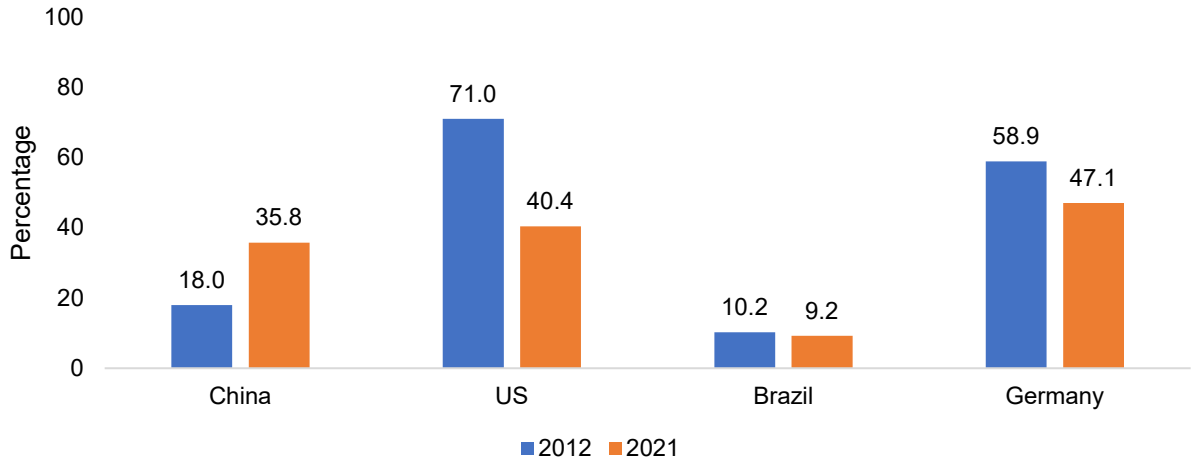
Figure 2.1. Top 4 concentration (%) of fertilizer and nitrogen compounds in main producing countries, 2012 and 2021



Note: Calculations based on adding company shares within each country for annual production turnover of fertilizers and nitrogen compounds at current prices (in US dollars applying year-over-year exchange rates).

Source: Euromonitor International.

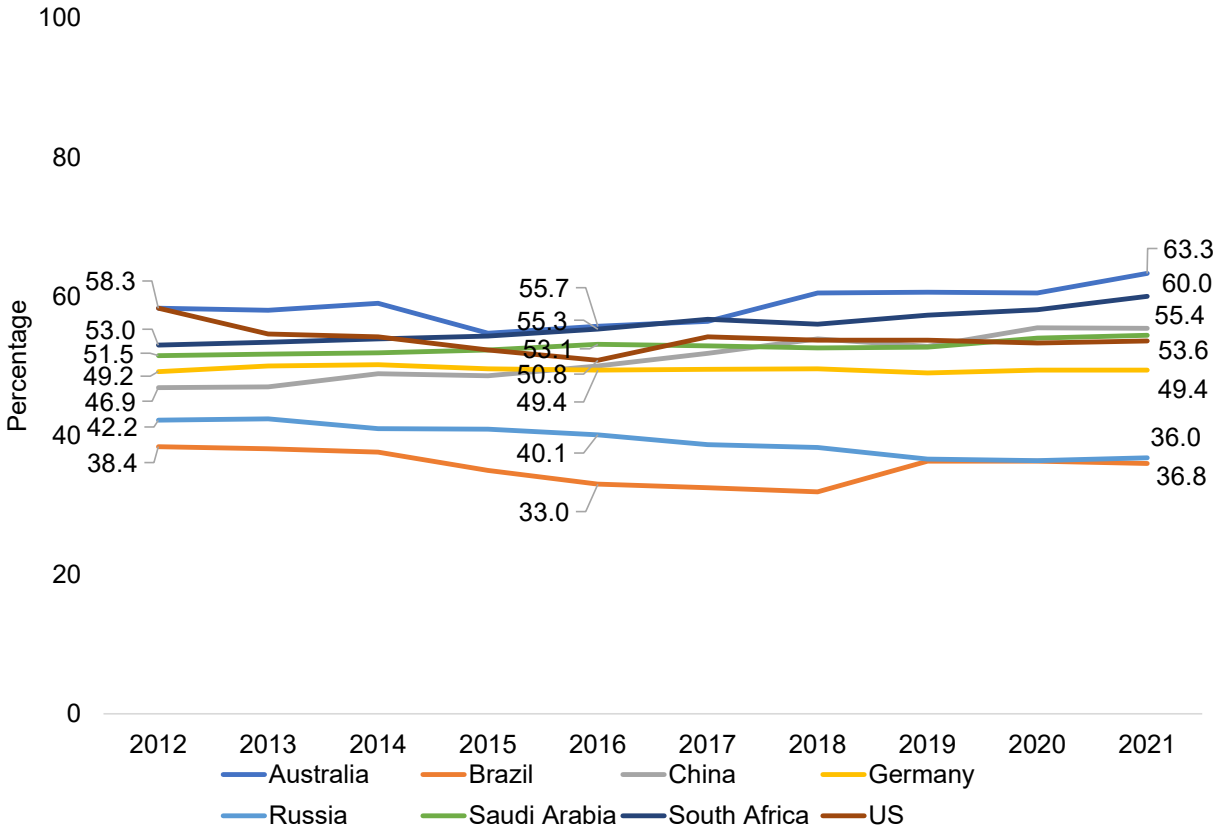
Figure 2.2. Top 4 concentration (%) of pesticides and other agrochemical products in main producing countries, 2012 and 2021



Note: Calculations based on adding company shares within each country for annual production turnover of pesticides and other agrochemical products at current prices (in US dollars applying year-over-year exchange rates).

Source: Euromonitor International**.**

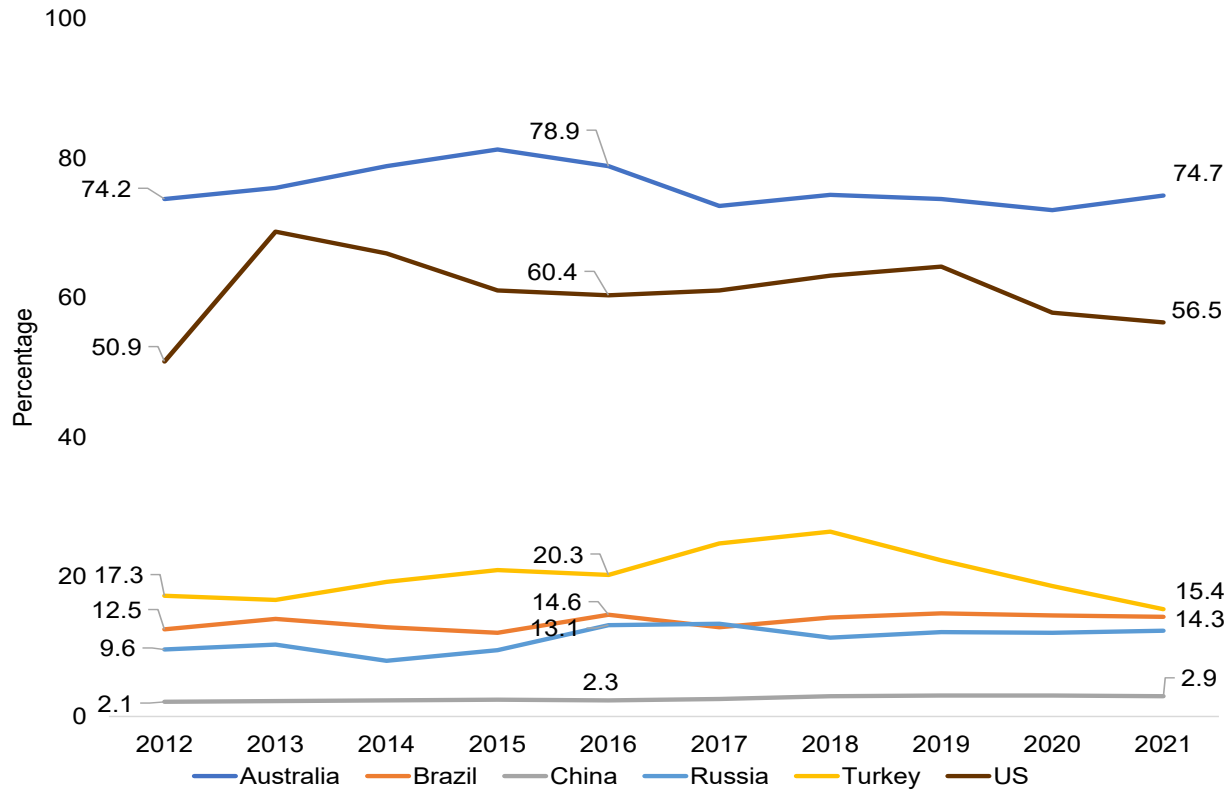
Figure 2.3. Top 4 concentration (%) of dairy processors in selected countries, 2012-2021



Note: Calculations based on adding company shares within each country for annual sales at retail selling price (in US dollars applying year-over-year exchange rates).

Source: Euromonitor International.

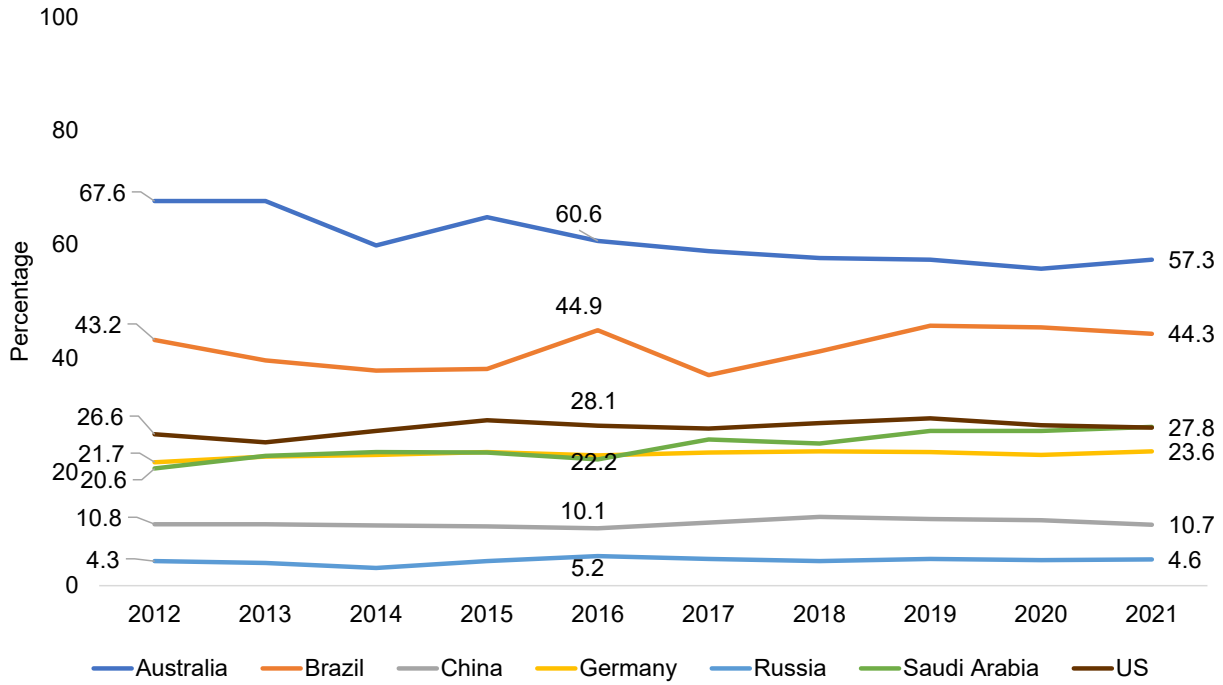
Figure 2.4. Top 4 concentration (%) of grain mill products in selected countries, 2012-2021



Note: Calculations based on adding company shares within each country for annual production at manufacturer selling price (in US dollars applying year-over-year exchange rates).

Source: Euromonitor International.

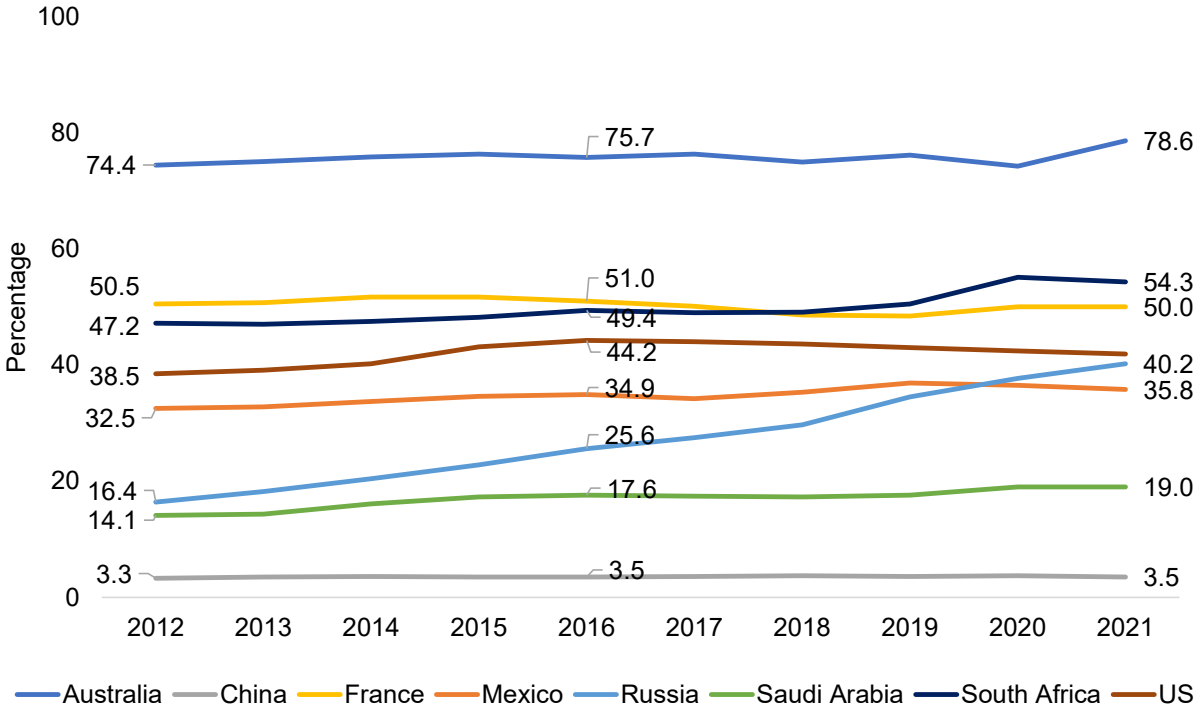
Figure 2.5. Top 4 concentration (%) of meat and meat products in selected countries, 2012-2021



Note: Calculations based on adding company shares within each country for annual production at manufacturer selling price (in US dollars applying year-over-year exchange rates).

Source: Euromonitor International.

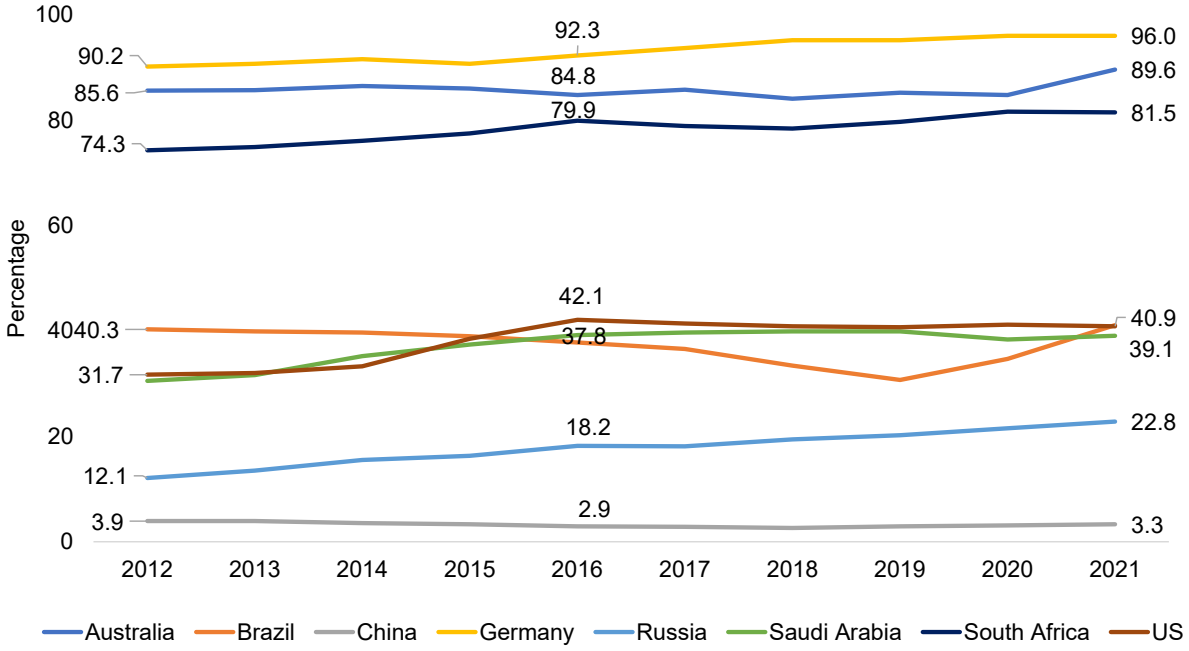
Figure 2.6. Top 4 concentration (%) of grocery retailers in selected countries, 2012-2021



Note: Calculations based on adding company shares within each country for annual sales at retail selling price (in US dollars applying year-over-year exchange rates).

Source: Euromonitor International.

Figure 2.7. Top 4 concentration (%) of supermarkets in selected countries, 2012-2021



Note: Calculations based on adding company shares within each country for annual sales at retail selling price (in US dollars applying year-over-year exchange rates).

Source: Euromonitor International.

Table 2.1. Summary of figures and estimates of concentration by segment and industry of the agri-food chain

Level	Industry/category	Figure/Estimate	Period	Country/Market	Source and/or Reference
Upstream	Fertilizers (ammonia, urea, monoammonium phosphate (MAP), diammonium phosphate (DAP), nitrogen-phosphate-potassium (NPK), phosphoric acid, potash)	Top 5 countries control more than 50% of world's production capacity in ammonia, urea, monoammonium phosphate (MAP), diammonium phosphate (DAP), nitrogen-phosphate-potassium (NPK), phosphoric acid, and potash.	2008-2009	Global	International Fertilizer Development Center (IFDC), Hernández and Torero (2011, 2013)
		China, India, Russia, and the US among the countries that dominate production capacity in the case of ammonia, urea, DAP/MAP, and phosphoric acid.			
		Russia and Canada control more than 50% of world's production capacity of potash.			
		Top four firms control more than half of the production capacity of each major country producer. Concentration of potash production at the country level is the most extreme case: in four of the five main potash-producing countries, the CR4 index is 100%. For DAP/MAP and NPK, four of the five main producing countries exhibit a CR4 over 60%, while for urea three countries show a CR4 over 50%.	2008-2009	Country level (main producing countries)	International Fertilizer Development Center (IFDC), Hernández and Torero (2011, 2013)
	Fertilizers and nitrogen compounds: nitrogen products associated with fertilizer production (nitric and sulphonitric acids, ammonia, ammonium chloride, ammonium carbonate, nitrites, and nitrates of potassium) and phosphate, potash, and compound fertilizers.	A global CR4 index of 56% is obtained for 2012 (compared to 43% in 1997) with China being the main producer (38%), followed by Russia (6%), India (6%), and Brazil (6%). The global level of concentration peaked in 2015 to 65% and has returned to 56% in 2021 where China (40%), Russia (6%), India (6%), and Brazil (4%) remain as the main producers.	1997-2012-2021	Global	Euromonitor International
		At the country level, the CR4 indexes among the top four producing countries have similarly either maintained or slightly increased between 2012 and 2021. In India and Russia, the CR4 index is above 40%, while in Brazil and China it increased from 24.5% and 11.5% to 27.6% and 14%, respectively. The same companies also remain among the top producers in each company and in the same ranking; the only exception is Yunnan Yuntianhua Co Ltd in China that was not among the top four producers in 2012 and became the most important producer in 2021 with a 4.2% of the total volume of sales.	2012-2021	Country level (main producing countries)	Euromonitor International
	Agrochemicals	Global CR4 index increased from almost 29% in 1994 to 53% in 2009.	1994-2009	Global	ERS-USDA, Fuglie et al. (2011)

Level	Industry/category	Figure/Estimate	Period	Country/Market	Source and/or Reference
Upstream	Agrochemicals	Syngenta (Switzerland), Bayer (Germany), BASF (Germany), DuPont (USA), Monsanto (USA), and Dow (USA), the 'Big Six', are linked to the proprietary seed industry, and controlled 75% of the global pesticides market.	2014	Global	Action Group on Erosion, Technology, and Concentration (ETC), IPES-Food (2017)
	Pesticides and other agrochemical comprise insecticides and herbicides, plant growth regulators and disinfectants (anti-sprouting products), and fungicides and rodenticides.	Compared to a global CR4 index of 52% in 1997 with the US being the main producer (27%) followed by Japan (9%), France (8%), and China (8%), in 2012 the concentration ratio increased to 64% with a substantial growth from China that concentrated 31% of the global production, followed by the US (16%), Brazil (10%), and Germany (7%). The level of concentration then peaked in 2015 with a global CR4 of 68% and has remained at 63% in 2021 where China (34%), US (14%), Brazil (8%), and Germany (7%) continue to be main producers.	1997-2012-2021	Global	Euromonitor International
		At the country level, CR4 index in China increased between 2012 and 2021 (from 18% to 35.8%), where Wuhai He Ye Chemical Engineering Co Ltd has continued to consolidate its position as the major market player. In the US and Germany, in contrast, the concentration ratio decreased but still remain over 40%, while in Brazil it has remained around 9-10%.	2012-2021	Country level (main producing countries)	Euromonitor International
	Seeds (crop seeds and biotechnology)	Market share of the four largest firms in the global seeds market increased from 21% in 1994 to 54% in 2009, based on firm sales data.	1994-2009	Global	ERS-USDA, Fuglie et al. (2011)
		Global CR4 index of 58% in 2011 using sales data, which further increased to 65% in 2014. Bayer CropScience-Monsanto (Germany-US) explains 30.1% of the global sales followed by DuPont-Dow (US), Syngenta (Switzerland), and Vilmorin & Cie (France) with 22.7%, 7.8%, and 4.4%, respectively.	2011-2014	Global	Action Group on Erosion, Technology, and Concentration (ETC), IPES-Food (2017)
	Maize	In maize, the CR4 index is 83%, where Monsanto alone has a 35.5% share and DuPont Pioneer another 34.5%.	2014	US	Begemann, S. (2015), Bryant et al. (2016)
	Soybeans	In soybeans, the CR4 is 76.2% where DuPont Pioneer and Monsanto have shares of 33% and 28%, respectively.	2014	US	Begemann, S. (2015), Bryant et al. (2016)

Level	Industry/category	Figure/Estimate	Period	Country/Market	Source and/or Reference
Upstream	Cotton	In cotton (upland) the CR4 is 91.4% where Bayer has a market share of 38.5% followed by Monsanto with a 31.2% share.	2015	US	AMS-USDA (2015), Bryant et al. (2016)
	Maize	In maize, the CR4 index is above 60% in 30 of the 32 countries covered and above 40% in the other two countries, while the HHI is above 1,500 in 27 of them; if the indicators are based on volume (instead of value), CR4 is over 60% in 28 countries and HHI is above 1,500 in 24 countries.	2016	Country level (32 countries, 65% of the global market value)	Kleffmann amis® AgriGlobe® database, OECD (2018a)
	Soybeans	For soybeans, the CR4 index is 42% in Ukraine while in the other six countries is above 60% in terms of both value and volume; the HHI is similarly over 1,500 in six of them, while in four countries is above 2,500.	2016	Country level (7 countries, 86% of the global market value)	Kleffmann amis® AgriGlobe® database, OECD (2018a)
	Rapeseed	For rapeseed, CR4 is above 60% in terms of value in 16 of the 17 countries and above 40% in the remaining country, while the HHI is over 1,500 in 12 countries; in terms of volume, CR4 is above 60% in 12 countries and the HHI above 1,500 in ten countries.	2016	Country level (17 countries, 62% of the global market value)	Kleffmann amis® AgriGlobe® database, OECD (2018a)
	Sunflower	For sunflower the CR4 index is above 60% across all countries in terms of value and only one country (Russia) has a CR4 below 60% in terms of volume (58%); the HHI in this market exhibits values over 2,500 across most countries.	2016	Country level (11 countries, 75% of the global market value)	Kleffmann amis® AgriGlobe® database, OECD (2018a)
Midstream	Livestock slaughter (steers and heifers; cows and bulls; hogs)	The share of steers and heifers slaughtered by the four largest firms increased from less than 40% in 1980 to 85% in 2015; for cows and bulls, from around 10% to close to 60%; and for hogs, from one-third to around two-thirds in the same period.	1980-2015	US	GIPSA-USDA (2016), Deconinck (2021)
	Processed food (37 food manufacturing industries)	In the 37 food manufacturing industries covered by the US Census data in 2012, 29 were unconcentrated (HHI below 1,500); five were moderately concentrated (HHI between 1,500 and 2,500); and three (specialty canning, flavoring syrup and concentrate manufacturing, and other snack food manufacturing) were highly concentrated (HHI above 2,500).	2012	US	US Economic Census, Saitone and Sexton (2017)
	Processed food (42 food manufacturing industries)	In the 42 food manufacturing industries covered by the US Census data in 2017, 23 showed a CR4 index above 40% and 11 above 60%, some of which are: other snack food manufacturing; animal (except poultry) slaughtering; specialty canning; soybean and other oilseed processing; cane sugar manufacturing; and breakfast cereal manufacturing. Only 35 industries report HHI data, and 5 showed a HHI above 1,500 where the breakfast cereal industry the highest (2,210).	2017	US	US Economic Census, Crespi and MacDonald (2022)

Level	Industry/category	Figure/Estimate	Period	Country/Market	Source and/or Reference
Midstream	Processed food (23 food manufacturing industries)	Data for 14 member states in 2012 across 23 product categories, show that baby food, frozen ready-cooked meals, and cereals and coffee exhibit the highest concentration levels, while ham, bread, and cheese exhibit the lowest levels. When averaging across the 23 product categories in each country, the supplier concentration varies from a HHI less than 1,400 in Germany to over 2,800 in Denmark, with a median of 2,100. In addition, average concentration increased between 2004 and 2012 across most countries.	2004-2012	EU (14 member states)	European Commission (2014)
	Processed food	A 2015 study by the Federal Economic Competition Commission (COFECE) using economic census data in Mexico reports estimated HHI less than 1,500 for sugar cane, vegetable oils and fats, cookies and pastries, among others; moderately concentrated markets in beer, prepared foods other than frozen foods, and condiments and dressings; and highly concentrated markets in snacks, breakfast cereals, and industrial baking.	2015	Mexico	Federal Economic Competition Commission (COFECE) Mexico, Deconinck (2021)
	Dairy products (butter and spreads, cheese, drinking milk products, yoghurt and sour milk products, and other dairy)	Except for Brazil and Russia, the concentration ratios are above or close to 50% and have generally remained rather stable or increased over time. China shows an 8.5-percentage points (pp) increase (from 46.9% in 2012 to 55.4% in 2021), followed by South Africa with a 7pp increase (from 53% to 60%), Australia with a 5pp increase (from 58.3% to 63.3%), and Saudi Arabia with a 2.9pp increase (from 51.5% to 54.4%). In Germany the ratio has remained rather stable at 49-50% while in the US it decreased from 58.3% to 53.6%.	2012-2021	Main country in each geographical region available	Euromonitor International
	Grain mill products (grain milling and breakfast cereals)	For this product category, only Australia and the US exhibit important levels of concentration. In the case of Australia, the CR4 maintained around 74-75% between 2012 and 2021 while for the US it increased from 50.9% to 56.5%. For the remaining countries (Turkey, Brazil, Russia, and China), the concentration levels are below 20% and have remained rather stable over the last decade.	2012-2021	Main country in each geographical region available	Euromonitor International
	Meat and meat products (red meat, white meat, and red and white meat products)	Australia exhibits the highest level of concentration, although it decreased from a CR4 of 67.6% in 2012 to 57.3% in 2021, followed by Brazil with a relatively stable CR4 of 43-44%. The other countries show concentration ratios below 30% that have generally maintained steady over time, except for Saudi Arabia that increased from 20.6% to 27.8%. In the US and Germany, CR4 indexes situate at 27.8% and 23.6%, respectively, in 2021, while China barely has a concentration ratio of 10.7% and Russia of 4.6%.	2012-2021	Main country in each geographical region available	Euromonitor International
Downstream	International traders (grain)	The four major corporations that produce, process, transport, finance, and trade food and agricultural commodities (known as the ABCD): ADM - Archer Daniels Midland (USA), Bunge (USA), Cargill (USA), and Louis	2011	Global	Murphy et al. (2012)

Level	Industry/category	Figure/Estimate	Period	Country/Market	Source and/or Reference
Downstream		Dreyfus Commodities (France), are estimated to account for up to 90% of global grain trade.			
	Food Service wholesalers	Two firms, Sysco and US Foods (formerly U.S. Foodservice), dominate this broadline distribution in the US with over 70% of the market.	2020	US	AMS-USDA (2022)
	Fast Food	Leading brand in fast food market is McDonald's with 21.4% of total revenues in 2018, followed by Starbucks with 7.5%, and KFC and Subway with 2.8% each.	2018	US	T4 (2021)
	Grocery retailers	In the US, the combined market share of the four largest grocery retailers increased from 14% in 1984 to 22% in 1994 and 55 % in 2001.	1984-1994-2001	US	Swinnen and Vandeplas (2010)
	Grocery retailers	Market share of the largest five food retailers in Europe reached over 80% in the 2000s.	2000	EU	European Commission (2014)
	Grocery retailers	Einarsson (2007) reports that by 2004 in the Nordic countries the market share of the largest three retailers in the grocery market was already 79.6% in Finland, 81% in Iceland, 82% in Norway, and 91.2% in Denmark and Sweden.	2004	Nordic countries	Einarsson (2007)
	Grocery retailers	US Census data up to 2013 show that the four leading grocery retailers have a combined share of close to 40% of the national market (compared to less than 20% in 1992).	1992-2013	US	US Economic Census, Saitone and Sexton (2017)
	Grocery retailers	In the period 1990 to 2015, the average HHI for food retail increased from 2,071 to 3,075 in rural counties from 1,617 to 2,924 in non-metropolitan small urban counties.	1990-2015	US	ERS-USDA and Çakir et al. (2020) cited in Crespi and Macdonald (2022)
	Grocery retailers	By 2012, the HHI varied from less than 1,200 in Italy to more than 3,900 in Finland, with a median of around 2,000. Yet, in contrast with concentration among food manufacturers, average retail concentration saw a decline between 2004 and 2012 in 16 of the 26 member states for which data are available, due to growth of retailers who had a small market share in 2004 or were not even present (such as discounters), but in the other ten member states retail concentration increased.	2004-2012	EU (26 member states)	European Commission (2014)
	Grocery retailers (supermarkets, other grocery (except convenience) stores, warehouse clubs, and supercenters)	The share of food sales by the top four retailers have been continuously growing from 31% in 2012 to 34% in 2019.	2012-2019	US	ERS-USDA (2021a)

Level	Industry/category	Figure/Estimate	Period	Country/Market	Source and/or Reference
Downstream	Grocery retailers (includes supermarkets, hypermarkets, convenience stores, discounters, and other grocery stores)	Euromonitor shows important (over 40%) and somewhat increasing concentration levels among several countries. Australia reports the largest CR4 in grocery retail (from 74.4% in 2012 to 78.6% in 2021), followed by South Africa (from 47.2% to 54.3%), France (around 50%), the US (around 40%), and Russia that reached 40.2% in 2021 (exhibiting a 23.8pp increase relative to 2012). Of the remaining countries, the CR4 increased from 32.5% to 35.8% in Mexico and from 14.1% to 19% in Saudi Arabia, while in China the concentration ratio remained at 3%.	2012-2021	Main country in each geographical region available	Euromonitor International
	Supermarkets (only retail outlets selling groceries within a selling space of 400-2,500 square meters; excludes discounters, convenience stores, and independent grocery stores)	In Germany, Australia, and South Africa, the CR4 index reached 96%, 89.6%, and 81.5%, respectively, in 2021 reflecting increases of 4-7pp from 2012. In the US and Saudi Arabia, CR4 levels reached around 40% in 2021, compared to 31% in 2012, while in Brazil the concentration ratio has remained relatively stable at 40-41%. Russia also shows an important increase from 12.1% to 22.8%, whereas in China the level of concentration is barely 3%.	2012-2021	Main country in each geographical region available	Euromonitor International

Note: For additional details and references refer to the main text.

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IFPRI HEADQUARTERS
1201 Eye Street, NW
Washington, DC 20005 USA
Tel.: +1-202-862-5600
Fax: +1-202-862-5606
Email: ifpri@cgiar.org