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Concentration and Competition in U.S. Agribusiness

James M. MacDonald, Xiao Dong, and Keith O. Fuglie

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James M. MacDonald, Xiao Dong, and Keith O. Fuglie

Abstract

Market concentration, and its impact on competition, has attracted growing public scrutiny as well as several Federal policy initiatives. Critics argue that increased concentration has led to higher consumer prices, lower prices paid for farm commodities, increased corporate profits, reduced wages, less innovation, and waning productivity growth. The issues surrounding concentration extend to agribusiness, particularly to three agribusiness sectors where concentration has increased over time: seeds, meatpacking, and food retailing. This report details how consolidation proceeded in each sector—with attention to the important driving forces—and the effects on prices and innovation. Because mergers among firms have played a role in each sector's consolidation, the report also describes Federal antitrust policy regarding mergers and its implementation in these sectors.

Keywords: agribusiness, market concentration, competition, meatpacking, food retailing, agrochemicals, crop seed, intellectual property rights, research and development

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A report summary from the Economic Research Service *June 2023*

Concentration and Competition in U.S. Agribusiness

James M. MacDonald, Xiao Dong, and Keith O. Fuglie

What Is the Issue?

Market concentration, and its impact on competition, has attracted growing public scrutiny. Critics argue that many industries have grown too concentrated, with fewer firms competing with one another and a consequent weakening of competition. The issues surrounding concentration extend to agribusiness, particularly to three agribusiness sectors where concentration has increased over time: seeds, meatpacking, and food retail. This report details consolidation in each of these industries, explains the driving forces behind increased concentration, and examines public policies aimed at encouraging competition, with a focus on the implementation of merger policy.

What Did the Study Find?

- Market concentration—measured by the share of industry sales held by the largest firms—has increased sharply over the last four decades in many seed, livestock, and food retail markets. In 2018–20, two seed companies accounted for 72 percent of planted corn acres and 66 percent of planted soybean acres in the United States. In 2019, the four largest meatpackers accounted for 85 percent of steer and heifer slaughter and 67 percent of hog slaughter. In most metropolitan areas, five to six store chains account for most supermarket sales.
- Economic theory and empirical analyses demonstrate that high concentration can facilitate the exercise of market power, with firms driving sales prices above—or livestock purchase prices below—the prices that would prevail in competitive markets.
- However, the relationship between concentration and market power is not tight, and high concentration can often result from factors like innovations or the realization of scale economies that improve productivity and reduce costs and prices.
- Competition often occurs in local and regional markets, especially in food retail sales and livestock procurement for meatpackers. Some local markets are highly concentrated, with just two to three firms competing with one another.

ERS is a primary source of economic research and analysis from the U.S. Department of Agriculture, providing timely information on economic and policy issues related to agriculture, food, the environment, and rural America.

- Increasing concentration reflected a consolidation of production into fewer but larger firms, driven by technological innovations, changes in market demand, and redesigned supply chains. Mergers among competitors played a significant role in increasing concentration in the seed sector, a contributing role in food retail, and a limited role in meatpacking.
- Opportunities to commercialize innovations in agricultural biotechnology and stronger protection for intellectual property rights over seed and related agricultural biotechnology innovations were major driver of seed sector consolidation. This was accompanied by more private research and development (R&D) investment in crop agriculture, rapid diffusion of improved crop varieties to farmers, and higher farm productivity. Stronger scientific and marketing links between seeds and agricultural chemicals were followed by a series of mergers among firms in these industries.
- Between 1990 and 2020, prices paid by farmers for crop seed increased by an average of 270 percent, while seed prices for crops grown predominantly with genetically modified (GM) traits rose by 463 percent, substantially more than commodity output prices. The increases in seed prices reflected to a large degree the higher productivity of improved crop varieties and provided a return on investments in R&D by seed companies.
- The transformation of meatpacking industries featured shifts of production to larger plants to realize economies of scale, as well as tighter vertical coordination among production and processing stages through reliance on contract arrangements in place of cash markets. Because mature livestock lose value if they are moved long distances for slaughter, packers acquire animals in local and regional markets, which can be highly concentrated.
- Food retail has undergone a long reorganization, featuring: (1) traditional supermarkets facing entry from new store formats like Walmart and Costco; (2) increasing store sizes, offering a wider variety of products; (3) the emergence of national chains, often realized through mergers and acquisitions involving local and regional chains; and (4) a growing reliance on data-driven distribution and inventory strategies within agrifood market chains.
- U.S. antitrust laws prohibit mergers that reduce competition. Antitrust enforcement agencies consider a wide range of evidence, including the likely impact of a merger on market concentration, when investigating the likely impact of a merger on competition.
- U.S. antitrust reviews played important roles in agrifood industry restructuring. To maintain market competition and incentives to innovate, antitrust reviews led to divestitures of some company assets in mergers involving the "Big Six" seed-chemical global leaders. Merger reviews have stopped or altered a few meatpacking mergers, but mergers have not been the primary source of consolidation in that industry. Food retail mergers frequently attract antitrust scrutiny, but the standards for review have changed along with regulators' understanding of the nature of competition in the sector.

How Was the Study Conducted?

The authors drew heavily on prior research—much of it done at the U.S. Department of Agriculture's (USDA) Economic Research Service—and on data from USDA sources, along with additional data from other U.S. Government and private sources, to describe recent market trends.

Concentration and Competition in U.S. Agribusiness

Introduction: Competition in Agribusiness, a Primer

Market concentration, and its impact on competition, has attracted growing public scrutiny. Critics argue that as many industries have grown more concentrated, fewer firms compete with one another. They argue that in turn the consequent weakening of competition has led to higher prices, increased corporate profits, reduced wages, less innovation, and waning productivity growth.

The economic research behind these arguments is summarized in two symposia published in the 2019 summer issue of the *Journal of Economic Perspectives*, a publication of the American Economic Association, which endeavors to keep members apprised of current major issues in the field.[1] Two recent books by academic economists summarized the new research and offered policy prescriptions (Baker, 2019; Philippon, 2019). The influential business magazine The Economist covered the new research and reported its findings in a series of articles.[2]

The coverage, and the research behind it, has influenced public policy. In July 2021, President Biden issued an executive order, Promoting Competition in the American Economy, calling for stronger antitrust enforcement and for greater promotion of competition throughout the Federal Government's regulatory and procurement activities. The order also expressed support for legislative initiatives aimed at greater competition in the economy and established a White House Council on Competition to further these goals.

The issues surrounding concentration, and its impact on competition, extend to agribusiness. The President's Executive order specifically referred to rising concentration in farm input industries and in the processing industries that buy from farmers. A recent article, by Lawrence J. White, an academic economist with extensive experience in competition policy, addresses the broader controversies and their application to agribusiness (White, 2022). Agribusiness concentration had been in the news following mergers among major global seed and agricultural chemical firms—Dow Chemical with DuPont and ChemChina with Syngenta in 2017, and Bayer with Monsanto in 2018. Each merger came under antitrust scrutiny in the United States and Europe, and each ultimately proceeded while subject to a series of divestitures intended to preserve competition. Agribusiness competition received further attention from a series of antitrust cases brought by major retailers and by the U.S. Department of Justice (DOJ) against chicken processors.

The arguments advanced in the new research are not without controversy. Some economists argue that concentration, properly measured, has not grown, and that the perceived impacts on pricing and innovation are not nearly as negative or widespread as their proponents assert (Winston, 2021; Ganapati, 2021; for specific application to agribusiness, see Sexton & Xia, 2018).

This report assesses developments in three important agribusiness sectors, each of which has seen increased concentration: seeds and agricultural chemicals, meat and poultry processing, and food retailing. The authors draw on extensive research at the U.S. Department of Agriculture's Economic Research Service (USDA,

[1] "Markups" and "Issues in Antitrust" in the Summer 2019 issue of the journal.

[2] For example, see "Corporate Concentration" (March 24, 2016); "A Lapse in Concentration" (September 29, 2016); "Market Concentration Can Benefit Consumers, But Needs Scrutiny" (September 2, 2017); "How Regulators Can Prevent Excessive Concentration Online" (June 28, 2018); "Capitalism is Becoming Less Competitive (October 10, 2018); and "Competition is Withering on Both Sides of the Atlantic" (November 20, 2018).

ERS) and elsewhere to track consolidation in each sector—including rising concentration, changes in vertical linkages, and corporate organization—and to assess the drivers of consolidation. The evidence is then evaluated for links from concentration to competition to pricing and to innovation in each sector. Finally, recent antitrust cases—primarily involving mergers—are reviewed to describe the policy issues and to explain how antitrust policy is applied in agribusiness.

Analyzing Concentration and Competition in Three Agribusiness Sectors

The three industries discussed in the report differ in important ways. Agricultural chemicals and seeds, at one end of the supply chain, provide inputs to farmers.[3] Research, aimed at developing new or improved chemicals and seeds, underlies the sector's performance and provides an important channel for competition among rival companies. The complex sector features many different markets for a range of regions, crops, and weed, microbial, or insect pests. Some markets include just a few rival sellers, creating significant concerns over competition and the effects on pricing and innovation.

Meatpacking, which for this report includes beef, pork, and chicken processing, procures live animals from farmers and ranchers, processes them into a vast array of meat products, and sells meat to further processors, food retailers, and exporters. Each species segment of the industry has grown more concentrated over time, with an especially striking consolidation in beef during the 1980s and 1990s. Competition concerns arise in the acquisition of livestock from farmers and ranchers and in the sale of meat products.

The three segments each feature distinctive business practices for obtaining live animals, and those practices also feature in competition disputes. Almost all chickens are raised under production contracts between growers and processors, in which processors provide chicks and feed to growers, who provide labor, capital in the form of housing and equipment, and utilities. Growers are paid for the services they provide, not for the animals they raise. In contrast, most cattle are purchased by packers through marketing contracts that specify quantity and pricing arrangements and that are reached before the animals are ready for slaughter. Hog production remains a hybrid of the two, with production contracts, marketing contracts, and some vertical integration in which a packer owns hog farms.

Food retailing encompasses two major sectors: (1) food service, such as restaurants, schools, prisons, and military bases, and (2) retail grocery, such as supermarkets and grocery stores that sell food for home consumption. This report focuses on the latter. The food retail sector underwent a striking transformation over the last 30 years as new store formats emerged to challenge supermarket chains. Some of the new formats offer a range of apparel and other nongrocery items in addition to food (Walmart is an example), while others offer a limited array of food items, often in large package sizes at low prices (Costco, for example). At the same time, many traditional supermarket chains expanded by building bigger stores with a wider array of products and by merging with one another. Other formats such as discount stores, drugstores, and dollar stores have also started carrying more food products, and online retail for food products is growing, too.

[3] Some crop seeds can be genetically modified to carry certain insecticides or to be tolerant of herbicides. Seeds can also be coated with insecticides aimed at other types of insects. These biochemical linkages create opportunities for gain from joint research and marketing efforts, so major firms produce both seeds and chemicals.

Major retail chains now are national, and nationwide food retail sales concentration has risen sharply in the last three decades. However, markets for retail food sales are local and often quite concentrated, with consumers limited to only a few different retail chains in an area. Because local markets can be concentrated, and because mergers have been important in the industry, antitrust policy regarding mergers has had consequential impacts in food retail.

Measuring Concentration

Market concentration in this report is measured in the same way as that is widely used in the broader national conversation about concentration and competition. Specifically, the report focuses on the two most widely used concentration measures: the four-firm concentration ratio (CR4) and the Herfindahl-Hirschman Index (HHI).

The CR4 is simply the four largest firms' combined share of a market or industry. In practice, the CR4 is most often based on the dollar value of sales—and hence the share of industry sales held by the four largest firms—but it can also be based on physical measures of output, such as tons of flour or beef produced, or on measures of production inputs, such as the number of animals processed. The measure, easy to calculate, has been reported for industries in the Census of Manufactures since 1947. Because of its long provenance and expansive coverage, the CR4 is widely used in Government statistical series and in private trade publications.

The HHI is more complex, defined as the sum of the squared market shares of the firms in an industry.[4] The CR4 and the HHI are highly correlated, but the HHI is more sensitive to the number of competing firms and the market shares of the largest firms. For example, the CR4 will be the same if there are four rivals, or three, or two (or just one). In highly concentrated industries with just a few rivals, the HHI will be sensitive to the number of rivals and their market shares.[5] Antitrust agencies consider a wide range of evidence, including HHIs, when evaluating mergers and detail their approach in horizontal merger guidelines available to the public. The guidelines, last revised in 2010, are currently under review.

Antitrust Policy

The country's principal antitrust laws are the Sherman Act of 1890, the Clayton Act of 1914, which was significantly amended in 1936 and 1950, and the Federal Trade Commission (FTC) Act of 1914. Two Federal agencies—the Antitrust Division of the DOJ and the FTC—share primary responsibility for public enforcement of the antitrust laws. However, private parties can also bring antitrust claims seeking damages, injunctive relief, and recovery of attorneys' fees, and private suits have played a role in antitrust litigation in agribusiness. The laws cover a range of business practices that might restrain competition and that can be grouped into three classes (Hovenkamp, 2005): (1) multilateral, horizontal restraints; (2) unilateral exclusionary practices; and (3) vertical practices.

Multilateral, Horizontal Restraints

Multilateral, horizontal restraints is a class that covers agreements among rival firms. Multilateral refers to agreements among multiple firms, while horizontal identifies the firms as competitors producing for the same market, and restraints refer to actions that restrain competition by limiting output compared with what it

[4] For example, if there were five firms in an industry, accounting for 30, 25, 20, 15 and 10 percent of production, then the HHI would equal $30^2 + 25^2 + 20^2 + 15^2 + 10^2$, or 2,250. The HHI can range as high as 10,000 (a single firm with a 100-percent market share); on the low side, an industry with 100 firms, each with 1 percent of the market, would generate an HHI of 100 (1,000 firms, each with a share of 0.1 percent, would yield an HHI of 10).

[5] With four equal-sized firms, the CR4 would be 100 and the HHI would be 2,500. If the number of equal-sized rivals fell to three and then to two, the CR4 would remain at 100, while the HHI would rise to 3,333 and then to 5,000.

would be in a competitive market. In turn, this class of practices encompasses collusion, such as agreements among rivals to fix prices or allocate production among themselves; mergers among rivals that might damage competition; and other agreements that might facilitate a reduction in competition. Each of these practices has featured in important recent antitrust cases affecting agribusiness.

Collusion is a per se violation of the Sherman Act, meaning that the practice itself is illegal, without reference to any weighing of the costs and benefits from the action. Convictions can result in substantial fines; in addition, collusion can be a criminal offense resulting in jail terms.[6]

Price-fixing prosecutions focus on evidence of conspiracy among rivals—telephone calls, meetings, emails, text messages, or documents that provide evidence that rivals communicated with one another and agreed to reduce output, raise prices, allocate bids, or otherwise limit competition. But firms don't necessarily need to explicitly agree with one another to recognize that reducing output or raising prices might be in their interest. Thus, a second element of multilateral, horizontal restraints covers practices that may facilitate such tacit agreement: for example, agreements among firms to share information or contractual features that may induce rivals to refrain from competing with one another. The law regarding such practices can be complex because the firms may claim that the practices have pro-competitive aspects, and so enforcers and courts must parse the different elements and their likely market effects.

This issue is of current salience in agribusiness. In July 2022, the DOJ filed a complaint against Cargill, Wayne Farms, and Sanderson Farms alleging that the firms shared information on wages and salaries paid to workers in their chicken processing plants to limit the firms' competition for those workers. In private antitrust lawsuits, buyers of meat and poultry products allege that processors have used a private statistical firm to collect and share plant-level production information and that such sharing is an anti-competitive practice that facilitates collusion among the processors through which they limit production and maintain high prices for their products.[7]

The antitrust statutes prohibit mergers that may substantially reduce competition.[8] If the enforcement agencies believe a prospective merger is illegal, they can seek injunctive relief in a Federal court (the FTC also has the option of challenging the merger in an administrative proceeding). If an enforcement agency signals opposition to a merger, the firms may decide to drop the merger or they may decide to contest the agency in court.

Federal courts have played a significant role in interpreting the antitrust laws and in making antitrust policy. However, many contested merger cases are settled before going to trial, with settlements typically involving the merging parties' divestiture of certain businesses and their assent to other conditions to meet agency concerns. For example, divestiture agreements played a significant role in the recent Bayer-Monsanto and Dow-Dupont mergers involving major producers of seeds and agricultural chemicals. The FTC required divestitures in two 2015 mergers of food retailers: Dollar Tree's acquisition of Family Dollar and Albertson's acquisition of Safeway.

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[6] In one high-profile agribusiness case featured in the movie called The Informant, the Justice Department charged five corporations with conspiracy to fix prices for the feed ingredient lysine. The 1996 case resulted in record fines at the time, as well as prison sentences for three executives, and was followed by separate cases involving other agricultural inputs.

[7] See United States District Court, Northern District of Illinois, in re Broiler Chicken Litigation, "Order Granting Preliminary Approval of Settlement Agreements Between End-User Consumer Plaintiffs and Tyson, Fieldale, Peco Foods and George's Defendants." See also Leonard (2017) for a summary of the issue.

[8] In practice, the DOJ and FTC divide responsibilities for merger enforcement according to expertise developed in specific industries. For example, the FTC reviews mergers in food retailing and in fertilizer manufacturing, while the DOJ has taken the lead in reviewing mergers in meatpacking and in agricultural chemicals and seeds.

Unilateral Exclusionary Practices

This class, unilateral exclusionary practices, concerns practices carried out by individual firms—hence unilateral practices—that exclude potential rivals from a market. Practices that aim to bar entry into a market by potential rivals come under this heading, as well as practices that serve primarily to raise rivals' cost of expanding production. Such actions are carried out by firms with extensive existing market power, and hence are of concern in highly concentrated markets.[9]

An example concerns agribusiness, when the FTC, in a 2022 complaint brought jointly with 10 States, alleged that the pesticide manufacturers Corteva and Syngenta aimed to exclude potential rivals from pesticide markets through the operation of loyalty programs with pesticide distributors, which sell pesticide products to retailers and directly to some farmers. The complaint alleged that the programs allowed the firms to maintain high prices for certain herbicides and insecticides after patents on the products had expired by blocking the entry of rival generic products and raising the generic producers' marketing costs.[10]

Vertical Practices

Vertical practices is a class concerned with practices that cut across the supply chain, such as a vertical merger between a processor and a supplier of inputs to that processor, or contractual relationships between a processor and an input supplier. Vertical practices can be multilateral, encompassing agreements among firms, or unilateral practices carried out by a single firm.

Antitrust policy focuses on the effect of a practice on competition, and particularly on whether a practice serves to facilitate output restriction and the exercise of market power in one part of the supply chain; whether it acts to deter entry into the supply chain, thereby also restricting output and facilitating the exercise of market power; or whether it enables a firm to better exploit some existing market power.

How Concentration Matters in Antitrust Enforcement

Concentration plays a role in antitrust enforcement, and high or rising concentration therefore occupies a place in debates over antitrust and competition policy. In economic analyses, firms in highly concentrated markets are more likely to have the capability to: (1) profitably reduce their own production or raise prices, and (2) profitably collude with rivals. However, economic theory does not provide clear guidance on specific levels of concentration that are inconsistent with a competitive market; moreover, economic analyses show that other market factors matter as well.

The evidence from economic analyses informs antitrust enforcement. For example, in determining whether a merger might be likely to reduce competition, enforcement agencies consider the level of concentration in a market as well as the likely effect of the merger on concentration. These agencies also consider the ease with which potential rivals may enter a market if the merged firm were to reduce output and raise prices, and the ease with which buyers can switch purchases to competing products.

[9] Firms might realize a dominant market position because they've developed a new product, or because they've realized ways to produce at lower costs than rivals, and thereby realize a strong and profitable market position by outcompeting their rivals. Such behavior is not a violation of antitrust laws. However, firms with high market shares can run afoul of the antitrust laws when they take steps to limit competition by interfering with the entry of rivals.

[10] United States District Court for the Middle District of North Carolina. Case No. 22-cv-828. September 29, 2022. See also "U.S. Federal Trade Commission Sues Pesticide Makers, Alleging Price Scheme," by Leah Douglas, Reuters News Service, September 29, 2022.

The agencies publicize their approach in the Horizontal Merger Guidelines, a document intended to provide useful information to courts, firms, and antitrust lawyers on agency procedures and the analyses that they intend to use to make a determination (DOJ and FTC, 2010). The Guidelines were first issued in 1968 and subsequently revised in 1982, 1992, 1997, and 2010. The revisions reduced the emphasis originally placed on market concentration in the 1968 Guidelines in favor of greater emphasis on entry conditions, competing products, and buyer behavior. The revisions also raised the threshold of concern for concentration.[11] As part of the 1992 and recent 2010 Guidelines, the agencies also examined the unilateral effects of mergers.[12]

Revisions to the guidelines are informed by developments in economics research and in legal commentary, and future changes to guidelines and to judicial interpretation of the laws will also be informed by more recent research developments.

Most antitrust cases focus on the exercise of monopoly power, or the ability of firms to restrict output and raise product prices above competitive levels and toward the price that would be charged by a monopoly. But antitrust policy is also concerned with monopsony power—the ability of firms to restrict input purchases and *reduce* prices paid for an input toward the price that would be paid by a single buyer (a monopsony). The key concern about both monopoly and monopsony power is that these practices allow firms to reduce competition either in product or input markets.

Monopsony power is a real concern in labor markets and in markets for agricultural products, where farmers may face very few buyers in some markets. In the last two decades, monopsony issues have arisen in agribusiness merger cases among meatpackers, chicken processors, dairy product processors, and grain exporters, and the 2010 merger guidelines added an explicit discussion of monopsony issues.

Other Policies Aimed at Competition in Agribusiness

Antitrust is an important policy tool aimed at encouraging competition in the economy, but it is not the only tool. USDA has the authority, under the Packers and Stockyards Act of 1921, to monitor, investigate, and regulate livestock and poultry markets to promote fair competition and to guard against deceptive and fraudulent trade practices. The department has issued regulations regarding the features of livestock and poultry contracts, with the goals of protecting growers against abusive practices and of encouraging greater competition in markets for livestock and poultry (Greene, 2016).

USDA also announced plans to invest $1 billion in American Rescue Plan funds to support the construction and expansion of meat and poultry processing facilities, with the money targeted to firms that were not among the four largest in beef, pork, chicken, or turkey processing. The competitive impact would come through the financing of the firms' entry into concentrated markets.

[11] Kwoka (2015) argues that under 21st century merger policy, agencies were likely to oppose mergers that reduced the number of rivals from three to two, or two to one, but have been less likely to oppose mergers that reduce the number of significant rivals from six to five, five to four, or four to three.

[12] In markets where products are more differentiated, the merger of two firms that supply close substitutes could substantially lessen competition. This allows for the merged firm to unilaterally increase prices or reduce quality. For example, in a market with three low-end food retailers and many high-end food retailers, the merger between two low-end food retailers could significantly reduce competition as discount food retailer consumers are unlikely to switch to high-end food retailers.

Consolidation, Competition, and Innovation in Crop Seeds

The U.S. crop seed sector has undergone significant structural change. It has become highly integrated with agricultural chemicals and more concentrated, with fewer and larger firms dominating seed supply. Seed prices, especially of genetically modified (GM) varieties, have risen substantially. At the same time, seed and biotechnology companies increased their spending on research and development (R&D) and brought substantial innovations to crop agriculture. During 2015–20, the sector underwent another round of major restructuring, with mergers reducing the number of major firms in the sector from six to four and the number of major U.S.-based companies from three to one. Structural change in the industry has generated controversy over how market power and control over intellectual property rights (IPRs) may affect the rate, direction, and distribution of benefits from technical change in agriculture.

Biotechnology and Expanded Intellectual Property Rights Spurred Structural Changes

Prior to 1970, most crop breeding—with the important exception of hybrid corn—was done in the public sector. Private seed companies were mostly engaged in multiplication and distribution of foundation seed provided by public institutions.[13] Farmers often saved a portion of their harvest for use as seed in subsequent seasons, periodically purchasing new seed to reestablish purity and quality or to adopt an improved variety. Some farmers and seed companies specialized in the production of "bin-run seed" (grain taken from their own crop harvest, cleaned of impurities, and perhaps treated with pesticides), which they would sell to other farmers for planting. Hybrid seed is an exception. Hybrid seed does not reproduce true-to-form, so to maintain yield, farmers have to repurchase hybrid seed each season from the seed companies that control the parental lines. The parental lines of the hybrids can be held as trade secrets. This exclusion mechanism acts as an incentive for private investment in breeding for crops where hybrid seed technology is viable. Corn was the first crop to be grown using commercial hybrid seed.

The passage of the 1970 Plant Variety Protection Act (PVPA) was designed to encourage seed companies to improve crop varieties beyond hybrid corn. Under the PVPA, breeders could obtain a Plant Variety Protection Certificate (PVPC), a form of IPR, for new varieties. Farmers were still allowed to save seed of varieties protected with PVPCs, but they (and other seed companies) could no longer sell bin-run seed to other farmers except under license from the PVPC owner. However, other seed companies and breeders could freely use protected varieties as parent material in their own breeding programs. The PVPA did stimulate some private R&D, but unevenly across crops. Private varieties gradually replaced public varieties in soybeans, but not in wheat and small grains, for example (Fuglie et al., 1996).

Advances in biotechnology provided a new means of improving crops by allowing genes with specific, inheritable traits to be inserted into crop varieties. However, development of GM varieties is expensive and risky, and without stronger IPR protection than that offered by the PVPA, there was limited incentive for the private sector to invest in GM varieties. In 1980 the Supreme Court ruled in *Diamond* v. *Chakrabarty* that biotechnology innovations were patentable, and in 1985 *Ex parte Hibberd* made it explicit that this included GM traits in crops. Utility patents offer much stronger IPR than the PVPA; patented crops or crop traits cannot be legally saved as seed by farmers or used by others in their breeding programs except under license

[13] Foundation seed refers to seed stocks of new varieties that have been multiplied from the small quantities of breeder seed produced when a new variety is bred. Foundation seed is produced under strict conditions to preserve genetic identity and purity. It is multiplied to produce certified or retail commercial seed for sale to farmers.

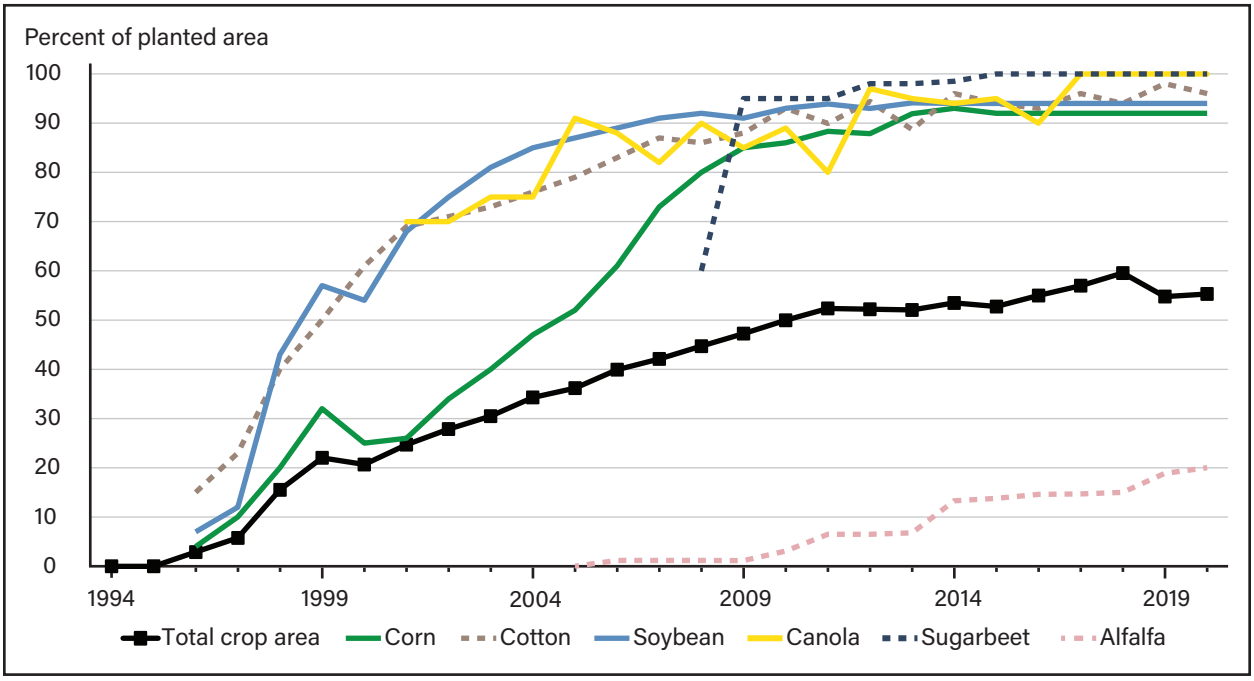
from the patent owner.[14] In 2001 in *JEM Supply* v. *Pioneer*, the court further extended patent protection to include new crop varieties as well as GM traits. Unlike trade secrets, which never expire, patents and PVPCs provide legal protection for intellectual property in seeds and traits for 20 years. Since 2001, companies have used both patents and PVPCs to protect IPR in new crop varieties, including for inbred lines used to produce hybrid seed.[15]

The technological opportunities opened up by biotechnology and the changes to IPR incentivized private investment in seed-biotechnology R&D. It also led to restructuring of the seed industry as companies with promising GM traits acquired or merged with companies that had assets in seed genetics and marketing networks. In the late 1990s, GM varieties of corn, soybeans, and cotton were introduced in the United States, and within a few years they became the dominant seed choice among farmers (figure 1). Later, GM varieties were widely adopted for canola and sugar beets. They are beginning to spread in alfalfa and have been planted on a small commercial scale in potato, papaya, squash, and apples (International Service for the Acquisition of Agri-biotech Applications [ISAAA], 2021). By 2020, about 55 percent of the total harvested cropland in the United States was grown with varieties having at least one GM trait. The most prevalent GM traits are herbicide tolerance and insect resistance.

[14] The stronger IPR protection afforded by utility patents, especially the lack of a breeders' exemption and an overly broad coverage of some patents, has led to concerns the utility patents could discourage innovation in seed. See U.S. Department of Agriculture, Agricultural Marketing Service (2023) for a discussion of these issues. The report proposes a number of measures that the USDA and other Federal agencies can take, including greater consultation between the U.S. Patent and Trademark Office (USPTO) and USDA in patent examination, to address these concerns.

[15] Three types of IPRs are thus now available for new plant varieties in the United States: (1) PVPCs are issued by the USDA and protect new varieties of seed-propagated crops and potatoes. PVPCs allow exemptions for breeders to use the variety as parent material for breeding other varieties and for farmers to save seed for their own use in subsequent plantings; (2) Utility patents are issued by the U.S. Patent and Trademark Office (USPTO) and protect new varieties of seed crops and plant traits. Utility patents do not have breeders- or farmers-use exemptions; (3) Plant patents are a special category of USPTO patents that protect clonally propagated plants except for potatoes. Plant patents are used mainly for flowers, ornamentals, and some tree crops. Each type of IPR lasts 20 years from the date of application. Only the United States, Australia, Japan, and South Korea issue patents for new crop varieties. Other countries award plant breeder rights like PVPCs, which provide exemptions for farmer-saved and breeder-use of protected varieties. However, some countries (e.g., Canada and EU member states) do issue patents for GM traits.

Figure 1
Diffusion of genetically modified (GM) crops in the United States, 1994–2020



Note: Planted area of crop varieties with GM traits diffused widely in the United States in the 1990s, though so far in relatively few crops. Corn, soybean, and cotton dominate the area planted with GM crops. Wheat, rice, barley, oats, sorghum, peanuts, sunflower, flax, beans, sugarcane, potatoes, vegetables, fruit, and nuts are primarily grown using conventional or non-GM planting material. By 2020, GM crops were grown on about 55 percent of all U.S. cropland. "Total crop area" in the figure is the share of U.S. cropland in GM crops, where cropland includes area planted to all field crops, area harvested of hay, sugarcane, tobacco, and commercial vegetables, and area in fruit and nut-bearing trees.

Source: Crop area in GM varieties from USDA, Economic Research Service and International Service for the Acquisition of Agri-Biotech Applications (ISAAA). Total crop area from USDA, National Agricultural Statistics Service (NASS).

Concentration in Seed Markets

Seed markets are complex value chains involving not only developers and retailers of crop varieties but also suppliers of improved parent lines (crop germplasm), seed treatments, and biotech traits and services. A company may focus on one or multiple aspects of these value chains and sell or license its products and services to or from other firms in the chain. Thus, a company that sells its proprietary seed varieties to farmers often has licensed technologies from other firms to produce the seed. For example, Monsanto was an early leader in developing biotech traits for corn, soybeans, and cotton, and incorporated traits into its own crop varieties as well as licensed these traits to other seed companies for use in these companies' proprietary varieties.[16] Firms with large patent portfolios have also entered into cross-licensing agreements with one another to acquire each other's technologies. Through cross-licensing agreements, firms may be able to significantly reduce or even avoid paying royalties or licensing fees.

Available public information on levels of concentration in markets for crop seed and biotech traits is quite limited. For retail seed markets, Government statistical agencies generally do not collect or report information on company sales, with the important exception of cotton. USDA's Agricultural Marketing Service (AMS) collected information on planted cotton area by variety until 2021 but discontinued this series thereafter. Whatever is known about market shares for retail seed in other crops is largely from private-sector

[16] Companies may seek utility patents for finished varieties, parent germplasm, biotech traits, seed treatments, and biotechnology transformation methods. Sometimes companies may jointly develop and share ownership of new technologies.

sources. Table 1 shows the evolution of market concentration in the U.S. corn, soybean, and cotton seed markets since 2000, including the likely effects of 2018–19 mergers between Dow Chemical–Dupont and Bayer–Monsanto. The four-firm concentration ratio (CR4) in corn and soybean edged upward over 2000–20, reaching 80 in corn and 75 in soybeans by 2016–17 (and may have risen again after the mergers). The CR4 in the cottonseed market was even higher, reaching 94 in 2018–20, although the dominance of any single company declined after 2007 following Monsanto's acquisition of Delta & Pine Land.[17] Cottonseed market shares have been quite dynamic among the leading companies, with the Bayer/BASF brands losing market share to Americot in recent years.

[17] As part of an antitrust settlement surrounding this 2007 acquisition, Monsanto relinquished its Stoneville seed brand to Bayer. In 2018, again as a result of an antitrust settlement, Bayer sold its Stoneville seed assets to BASF when it acquired Monsanto. See the section below on Mergers and Merger Policy in the Seed Industry.

Table 1
Market shares for U.S. corn, soybean, and cotton retail seed, 2000–20

Corn (percent seed sales)	2000–03	2004–07	2008–11	2012–15	2016–17	Post-mergers[1]	2018–20 estimate[2]
Monsanto	11.2	21.4	34.0	35.4	33.3	Bayer	33.3
DuPont Pioneer	36.0	31.3	31.5	35.4	34.7	Corteva	38.3
AgReliant	2.5	4.8	6.0	6.8	6.8	AgReliant	6.8
Syngenta	4.7	10.3	7.5	5.7	5.0	Syngenta	5.0
Dow Chemical	5.2	3.6	4.1	5.7	4.1		
All others	40.5	28.6	16.9	11.1	16.1	All others	16.1
Total	**100**	**100**	**100**	**100**	**100**	**Total**	**100**
Seed retail value (million $/year)	$2,110	$3,023	$6,056	$8,437	$8,483		$7,910
Soybeans (percent seed sales)	**2000–03**	**2004–07**	**2008–11**	**2012–15**	**2016–17**	**Post-mergers[1]**	**2018–20 estimate[2]**
DuPont Pioneer	19.9	24.9	29.3	33.3	31.9	Corteva	37.7
Monsanto	21.9	23.4	28.2	27.6	28.2	Bayer	28.2
Syngenta	3.4	10.4	10.5	10.0	9.2	Syngenta	9.2
AgReliant	1.1	1.9	1.8	3.1	3.0	AgReliant	3.0
Dow Chemical	1.9	1.6	1.9	4.8	5.8		
All others	51.8	37.8	28.2	21.3	21.9	All others	21.9
Total	**100**	**100**	**100**	**100**	**100**	**Total**	**100**
Seed retail value (million $/year)	$1,501	$1,926	$3,468	$4,385	$4,762		$4,740
Cotton (percent crop area)	**2000–03**	**2004–07**	**2008–11**	**2012–15**	**2016–17**	**Post-mergers[1]**	**2018–20 actual[2]**
Bayer	3.9	30.3	45.1	35.2	19.6	BASF[3]	10.5
Dow Chemical	1.5	2.5	10.0	16.3	13.6	Corteva	17.5
Americot	0.0	0.9	5.8	10.6	24.7	Americot	27.2
Monsanto[3]	12.7	9.6	34.3	30.6	34.2	Bayer[3]	38.4
Delta & Pine Land[3]	70.0	49.4					
All others	12.0	7.4	4.8	7.2	7.8	All others	6.5
Total	**100**	**100**	**100**	**100**	**100**	**Total**	**100**
Seed retail value (million $/year)	$611	$816	$983	$1,090	$856		$966

$ = U.S. dollars.

Note: For corn and soybean seed, two companies account for about 70 percent of U.S. sales. The cottonseed market was dominated by a maximum of two companies until around 2016, when market shares become more evenly split among three or four seed companies.

[1] In the 2018 mergers: (1) The agricultural divisions of DuPont Pioneer and Dow Chemical merged to become Corteva, and (2) Bayer acquired Monsanto while selling its seed division to BASF.

[2] Post-merger market shares for corn and soybean are based on 2016–17 shares of the relevant companies; post-merger market shares for cotton are actual shares in 2018–20.

[3] Monsanto acquired Delta & Pine Land in 2007, and as part of the merger agreement with U.S. Department of Justice, it sold Stoneville and FiberMax cottonseed brands to Bayer. When Bayer acquired Monsanto in 2018, these brands were sold to BASF.

Source: Company market shares for corn and soybean are from Ciliberto et al. (2019), which is based on proprietary GfK Kynetec data (2000–11) and Farm Journal Magazine (2012–17). Company market shares for cotton are from USDA's Agricultural Marketing Service, Cotton Varieties Planted, Annual Bulletin (discontinued after 2020). Seed market retail values are derived from USDA's National Agricultural Statistics Service (2000–15) and USDA's Economic Research Service cost-of-production estimates (2016–20).

Regarding other crops, concentration is likely to be high for canola, sugar beet, and alfalfa seed, for which GM traits are popular, and probably lower in markets where conventional seed varieties predominate and where public-sector varieties and farmer-saved seed continue to be widely used (e.g., for wheat and other small grains, peanuts, and dry beans). The market for vegetable seeds appears to be dominated by private-sector varieties but is quite diverse across species. Large seed-chemical companies like Bayer and Syngenta have significant investments in proprietary vegetable seeds, but there are also a number of midsized companies (including several Dutch companies) that have a significant presence in U.S. and global seed markets for specific vegetables.

Markets for GM traits are thought to be highly concentrated, though there is very limited public information available. Monsanto, an early leader in the development of GM crops, established a dominant position in GM traits in the 1990s and 2000s. By 2009, GM traits owned or licensed by Monsanto were used on 95 percent of soybean acres, 81 percent of corn acres, and 79 percent of cotton acres in the United States (Moschini, 2010). Licensing and cross-licensing of GM traits are widely practiced in the industry, and a single variety may have "stacked traits" licensed from multiple companies.[18] Little public information is available regarding licensing fees and practices (Jefferson et al., 2015). While some of the early patents for GM traits have expired or are soon expiring, it is not clear whether generic versions of these traits will become available for commercial use.[19]

Another perspective on concentration in seed markets is ownership of IPRs over new crop varieties and germplasm. A condition of receiving IPRs is public disclosure about the invention, and comprehensive statistics on patents and PVPCs are available from Government agencies. However, many patented inventions never see commercial success. So, while statistics on IPRs can reveal a great deal about innovation activity in an industry, they are an imperfect measure of market power and concentration. Over 2001–21, the USDA issued 8,407 PVPCs for new crop varieties, and during 1976–2021 (mostly after 2001), the U.S. Patent and Trademark Office (USPTO) issued 17,208 utility patents for new crop varieties or closely related innovations.[20] Patents and PVPCs may be issued for the same variety.[21] A breakdown of IPR ownership is shown in table 2. Seventy-one percent of the utility patents and 58 percent of the PVPCs for new varieties were assigned to the three largest seed companies (Bayer, Corteva, and Syngenta, including their legacy companies, or companies they had merged with or acquired). IPR ownership shares of these three companies were significantly higher for GM crops than non-GM crops.[22] Nonetheless, even for non-GM crops, ownership concentration for new varieties appears to be quite high; typically, only from one to four companies account for most of the IPR issued for new varieties of a single crop. Sometimes midsized companies may have a dominant share of IPR. Among vegetable crops, for example, European seed companies like Rijk Zwaan and

[18] Crop varieties with stacked traits are varieties in which more than one GM trait has been inserted into their genome. Stacked traits may convey both herbicide tolerance and insect resistance, tolerance to more than one type of herbicide, resistance to more than one kind of insect pest, or another trait.

[19] To use a GM trait in crop production, regulatory approval must be secured and maintained over time in each country where the seed is grown. The intended use of the harvested crop (food or animal feed) may also require regulatory approval in countries to which the crop may be exported. Costs for maintaining regulatory approvals are normally borne by the patent holder or licensee. If these regulatory approvals lapse, then those traits can no longer be used in commercial varieties or in the crops sold for commercial use in those countries.

[20] Lists of PVPCs are available from the USDA, Agricultural Marketing Service. Utility patent counts were obtained through searches of the online USPTO patent database. They include patents in class A01H, "New plants or processes for obtaining them" and with at least one of the following keywords in the title: "variety," "cultivar," "inbred," "line," or "hybrid." Not included are patents for plant breeding or seed production methods, GM traits, or genetic sequences.

[21] A comparison of variety names in soybean patents and PVPCs issued over 2001–21 indicates that about one-third of new varieties had both types of IP protection.

[22] "GM crops" are crops for which most seed used has one or more GM traits. These include corn, soybeans, cotton, canola, and sugar beet. Alfalfa, where the share of area in GM traits is rising, is also included in this group.

Enza Zaden may hold a dominant share for certain species. Public institutions like universities and the USDA also hold significant numbers of PVPCs for new crop varieties. Public institutions are assignees (owners) to 1,560 of the 8,407 PVPCs issued over 2001–21. Some of these are jointly owned with private companies. A complete account of public ownership of utility patents for crop varieties was not available for this study.

Table 2

Ownership of intellectual property rights (IPRs) over new crop varieties in the United States

Crop	Utility patents issued 1976–2021							Plant Variety Protection Certificates issued 2001–21							
	Total	Bayer	Corteva	Syngenta	Other major seed company in this market		BCS share (percent)	Total	Public sector	Bayer	Corteva	Syngenta	Other major seed company in this market		BSC share (percent)
GM crops															
Soybean	5,308	2,490	1,291	384	778	Stine	78	1,912	79	640	1,027	124	32	BASF	94
Corn	6,004	2,324	3,012	358	80	Limagrain	95	1,709	12	600	896	187	3	Limagrain	98
Cotton	466	250	65	2	65	BASF	68	424	43	207	3	1	122	BASF	50
Canola/Rape	241	36	188	0	4	BASF	93	30	18	1	5	0			20
Alfalfa	98	4	19	1	55	Land O'Lakes	24	17	2	0	9	0	3	Land O'Lakes	53
Non-GM crops															
Wheat	361	97	185	1	5	Limagrain	78	1,049	439	178	156	165	49	Limagrain	48
Barley	34	6	0	0	4	Highland	18	106	40	11	0	2	15	Busch	12
Rice	146	1	0	0	34	Ricetec	1	101	80	0	0	0			0
Sorghum	98	14	70	0			86	100	7	0	92	0			92
Oat	3	0	0	0	1	General Mills	0	84	76	0	0	0			0
Peanut	2	0	0	0			0	101	75	0	0	0	10	ARC	0
Sunflower	74	0	50	1			69	30	0	0	23	5			93
Bluegrass	3	0	0	0	2	Pure Seed	0	174	51	0	0	0	44	Pure Seed	0
Fescue	3	0	0	0			0	294	117	0	0	1	59	Pure Seed	0
Beans	109	49	0	11	22	Limagrain	55	251	59	68	0	45	21	ADM	45
Peas	60	39	0	11			83	213	16	39	0	23	24	Limagrain	29
Potato	65	0	0	0	24	Frito Lay	0	453	133	4	0	0	68	HZPC Holland	1
Tomato	390	241	0	14	35	Rijk Zwaan	65	52	7	27	0	6	4	Limagrain	63
Lettuce	421	49	0	35	140	Rijk Zwaan	20	301	2	61	0	42	26	Limagrain	34
Pepper	201	142	0	7	15	Enza Zaden	74	124	4	115	0	2			94
Cucumber	80	39	0	0	11	Enza Zaden	49	7	0	7	0	0			100
Spinach	77	44	0	0	23	Rijk Zwaan	57	9	2	3	0	0	4	BASF	33
Celery	38	0	0	0	31	Duda	0	11	0	1	0	4	3	Duda	45
Onion	15	5	0	0			33	29	12	9	0	0			31
Watermelon	66	28	0	16			67	26	3	5	0	16			81
Melon	73	24	0	8	8	Rijk Zwaan	44	17	0	2	0	12			82
GM crops	12,117	5,104	4,575	745			86	4,092	154	1,448	1,940	312			90
Non-GM crops	5,091	1,052	543	187			35	4,315	1,406	554	271	329			27
All crops	**17,208**	**6,156**	**5,118**	**932**			**71**	**8,407**	**1,560**	**2,002**	**2,211**	**641**			**58**

BCS = Bayer, Corteva, and Syngenta; GM = genetically modified.

Note: The great majority of utility patents for new crop varieties have been issued since 2001. Companies often seek and obtain Plant Variety Protection Certificates (PVPCs) and utility patents for the same variety. Some PVPCs and patents are co-owned by public institutions and private companies (these are assigned to the public sector in the table). Intellectual property holdings for Bayer, Corteva, Syngenta, and other listed companies include patents and PVPCs issued to legacy companies and subsidiaries (e.g., Bayer includes Monsanto; Limagrain includes Vilmorin). Figures for Stine include patents issued to Stine Seeds, Mertec, and MS Technologies. Stine also co-owns more than 800 soybean patents with Monsanto (these are included in the Bayer figure). Patents issued to Bayer for new crop varieties are assigned to BASF (a condition of Bayer's acquisition of Monsanto in 2018).

Source: Patent statistics are from the U.S. Patent and Trademark Office; PVPC data are from USDA, Agricultural Marketing Service.

Market Power, Innovation, and Seed Prices

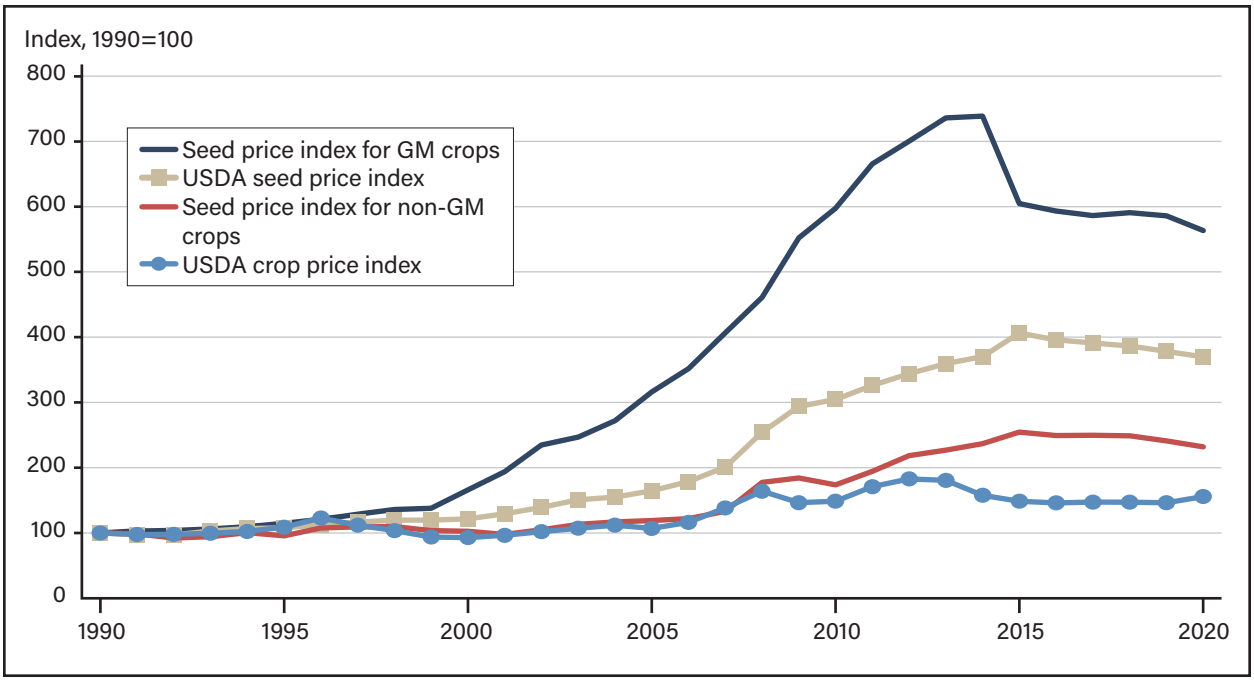
Patents (and PVPCs to a lesser extent) offer owners of IPRs a temporary legal monopoly over the use of their inventions. For inventions with market value, IPRs afford firms a degree of market power to set prices for the products that embody these inventions. The profits earned from price premiums are a return for R&D investments and other costs to commercialize the invention. While high prices from market power reduce economic welfare, market power can increase economic growth and welfare over the long run if it incentivizes firms to invest more in R&D. This trade-off between short-term welfare losses and long-term welfare gains underlies what is often a tension between antitrust and IPR policies. Moving from a system where privately owned inventions replace publicly financed inventions provided to users at nominal cost also affects who pays for, and who benefits from, technological change in agriculture. Inventions by private firms are financed by the price premiums they are able to charge users. Historically, public institutions like the USDA or land grant universities provided their inventions freely to users, but now they may similarly obtain patent rights and charge licensing fees for commercial use of their innovations.

Apart from whatever market power an IPR might confer, a firm's ability to exercise market power may be affected by the concentration levels in an industry. Economic theory suggests that some degree of market power (either from IPR or concentration) is necessary to incentivize private R&D. However, too much concentration may reduce R&D if the lack of competition takes away firms' incentive to innovate. If new product introduction entails high fixed costs (because of the costs of R&D and meeting regulatory requirements for product introductions), there can be significant barriers to entry for new firms, further limiting competition and potential new sources of innovation.

At the same time that U.S. seed markets became more concentrated, seed prices rose significantly, especially for GM varieties (Shi et al., 2009, 2010). However, the evidence is mixed on whether market concentration led to higher seed prices or whether other factors, such as IPR and the higher development costs of GM seed, may have been more important determinants of seed price inflation.[23] Between 1990 and 2020, the average price farmers paid for seed rose by 270 percent, compared with commodity price inflation of 56 percent. For crops planted predominately with GM seed (corn, soybeans, and cotton) seed prices rose by an average of 463 percent (figure 2). Despite their higher cost, GM crop varieties brought significant productivity gains to farmers, partly through higher yield but also by lowering farm production costs as genetic traits substituted for other inputs. For example, GM traits conferring insect resistance reduced the need for insecticide applications, and GM traits for herbicide tolerance provided a substitute for mechanical tillage, reducing labor, machinery, and fuel previously used for weeding. It appears that productivity gains more than paid for the higher cost of seed. Ciliberto et al. (2019) estimated that GM traits in corn and soybeans added value to the U.S. economy of over $5 billion per year, with 44 percent of this amount retained by farmers and 56 percent going to seed companies. A meta-analysis of studies on the economic impacts of GM traits worldwide reached a similar conclusion: The adoption of GM varieties had conferred significant profit to farmers despite the varieties' higher seed cost (Klümper & Qaim, 2014).

[23] The most comprehensive analysis of this issue, an OECD study in 2018 that covered multiple crop sectors in the United States and European countries, found no significant correlation between market concentration and seed prices for field crops (OECD, 2018). The study also found that for European field crops (which excluded GM crops) there was no significant relationship between concentration and the rate of introduction of new crop varieties.

Figure 2
U.S. retail seed prices for genetically modified (GM) and non-GM crops, 1990–2020



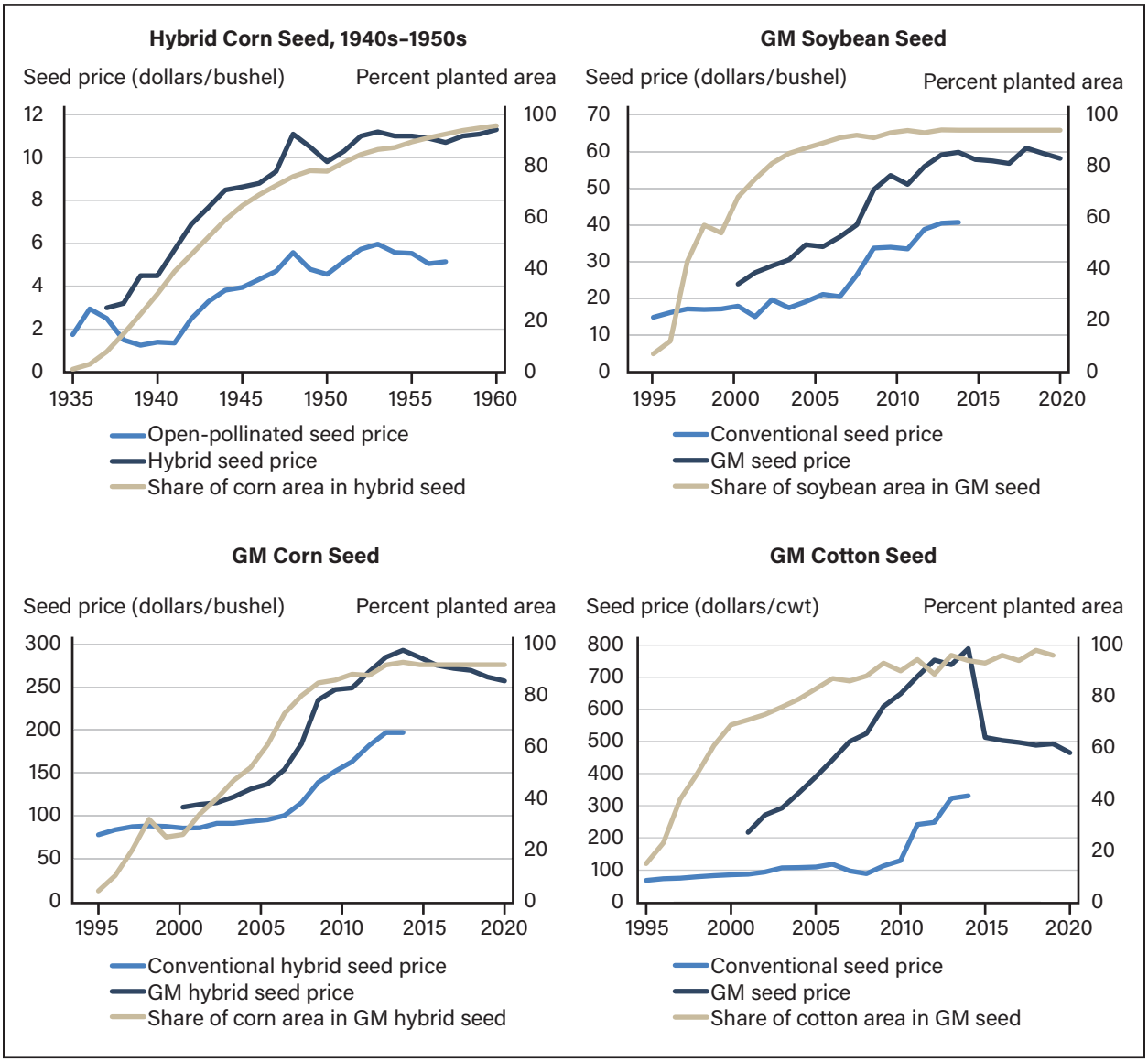
Note: Average U.S. prices for GM seed increased substantially in the first decade of the 2000 millennium but have since retreated somewhat. Prices for non-GM seed have also grown faster than crop prices over the past decade. Rising prices for seed partly reflect better seed quality from breeding and genetics that have raised farm yield and productivity.

Source: USDA crop and seed price indexes from USDA, National Agricultural Statistics Service (NASS). The seed price index for GM crops is the simple average of seed price indexes for corn, soybean, and cotton. The price index for non-GM crops is a simple average of seed price indexes for wheat, barley, oats, sorghum, rice, flaxseed, potatoes, and peanuts.

The increase in seed prices enabled companies to spend more on crop R&D and accelerate the rate of new variety introductions with higher productivity potential. In fact, the rise in seed prices for GM crops is not unlike what happened to seed prices when hybrid corn was introduced in the 1940s and 1950s (figure 3). Both innovations significantly raised farm productivity and profitability, and despite the higher seed cost, farmers quickly adopted them. Furthermore, the higher seed prices that companies were able to charge supported greater investment in R&D. Coinciding with the introduction of GM varieties, total R&D spending on crop improvement by the seven largest seed companies (including their legacy companies[24]) increased from under $2 billion in 1990 to over $7 billion by 2014, closely tracking the increase in company revenues from seed and agrichemical sales (figure 4). Since 2014, both crop R&D spending by these firms and their revenues declined before recovering some lost ground in 2021. As a group, these companies have fairly consistently invested about 10 percent of their agricultural revenues in R&D.

[24] These companies are Bayer, Corteva, Syngenta, BASF, Limagrain, KWS and Rijk Zwaan. Legacy companies include Monsanto, Dupont, Pioneer, Dow Chemical, Seminis, AstraZeneca, Aventis, Novartis, Ciba-Geigy, Sandoz, and 15 others. As a group, these estimates of the R&D spending and sales by these firms refer only to their agricultural business segments.

Figure 3
Seed prices and seed-embodied innovations

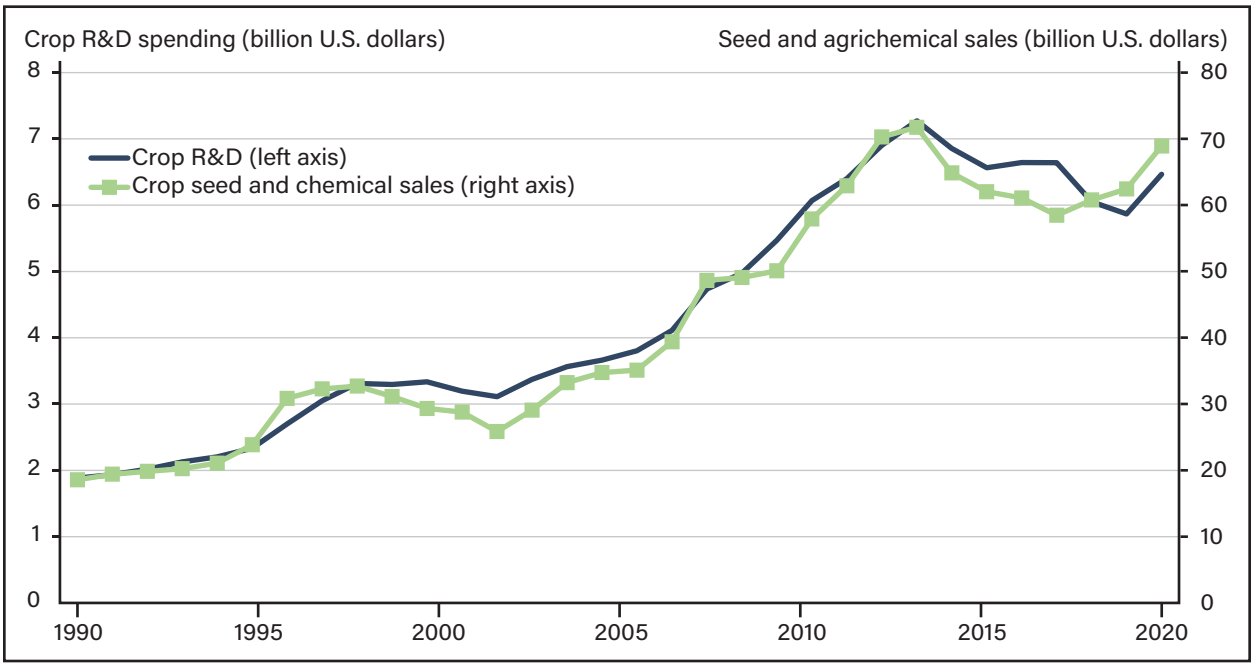


GM = genetically modified; cwt = hundredweight.

Note: The USDA stopped reporting separate seed prices for hybrid and non-hybrid seed and GM and non-GM seed once the new seed technology had been adopted by a large majority of farmers.

Source: USDA, National Agricultural Statistics Service (NASS), Agricultural Statistics Annual Yearbook. USDA, NASS stopped reporting seed prices for individual crops after 2015. Seed prices over 2016–20 are derived from USDA, Economic Research Service Cost-of-Production estimates.

Figure 4
Crop R&D spending and seed and chemical sales revenue by major companies worldwide, 1990–2020



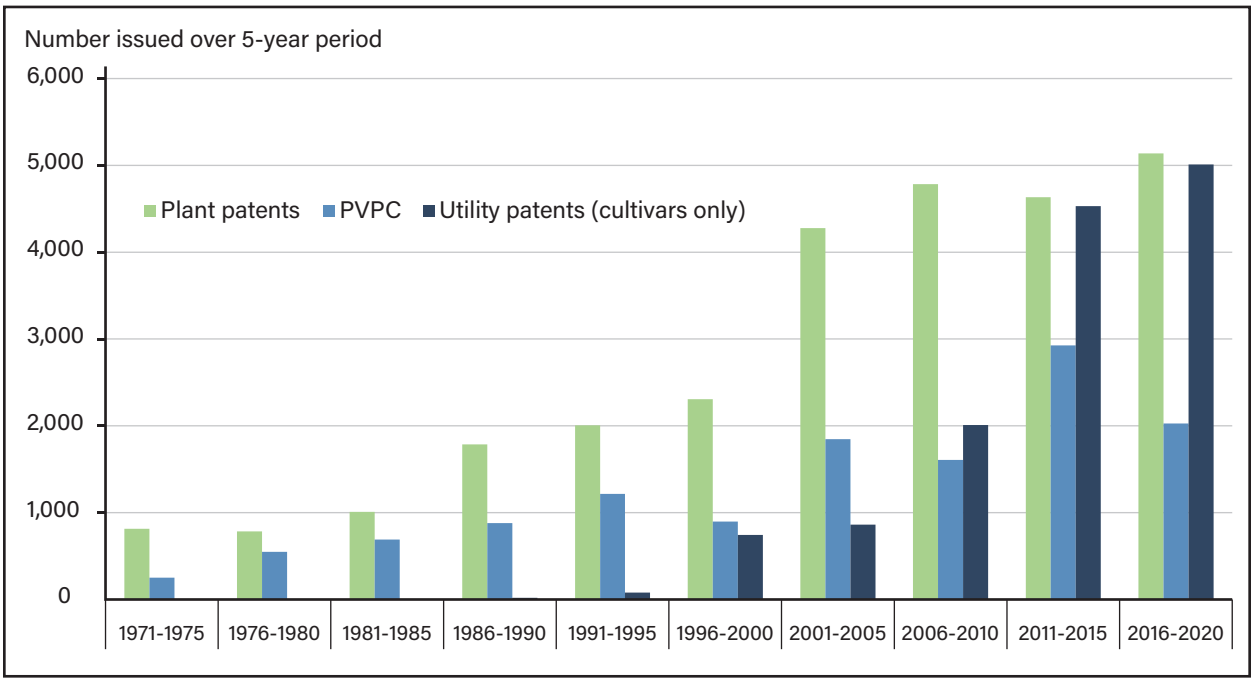
R&D = research and development.

Note: The figure shows the combined global crop R&D spending and sales revenues of the world's seven largest seed companies: Bayer, Corteva, Syngenta, BASF, Limagrain, KWS, and Rijk Zwaan, plus 25 legacy companies that have merged with or been acquired by these firms since 1990. Revenue includes sales of seed, agrichemicals, and other crop improvement products and services. The rising value of sales of agricultural seed and pesticides has been accompanied by rising investment by these companies in R&D. Collectively, the companies have consistently invested about 10 percent of their annual sales of agricultural products into R&D.

Source: USDA, Economic Research Service, based on company financial reports and other sources.

The increase in private crop R&D not only led to the commercialization of GM crops but accelerated the pace of crop technology development overall. In the 5 years from 2016 to 2020, a total of 5,137 plant patents, 5,010 utility patents, and 2,028 PVPCs were issued for new crop varieties, more than double the number of issues from a decade earlier (figure 5). Magnier et al. (2010) found that over 1997–2009, farmers increased their pace of corn variety turnover, with the average commercial life of a newly introduced hybrid falling from around 4 to 5 years in 1997 to under 3 years by 2009. The authors attributed this to an accelerated rate of product innovation.

Figure 5
Issuances of intellectual property rights (IPRs) for new crop varieties, 1971–2020



PVPC = Plant Variety Protection Certificates.

Note: Utility patents include patents issued for crop varieties, cultivars, hybrids, inbreds, and breeding lines. Plant patents are a special patent category for vegetatively propagated crops, excluding potatoes. Utility patents and PVPCs may be issued for the same cultivar. The number of new crop varieties developed and awarded IPRs grew steadily from the 1970s to the 2000s and remained at roughly this peak level during the 2010s.

Source: Utility and plant patent data are from the U.S. Patent and Trademark Office (USPTO); Plant Variety Protection Certificate (PVPC) data are from USDA, Agricultural Marketing Service.

Mergers and Merger Policy in the Seed Industry[25]

In 2015, six large firms dominated global markets for seeds and agricultural chemicals: BASF, Bayer, Dow Chemical, DuPont, Monsanto, and Syngenta (table 3). Sometimes referred to at that time as the "Big Six," these firms produced and sold crop protection products (primarily herbicides, insecticides, and fungicides), seed treatments (seed coatings to protect against insects or fungi), crop seeds, and seed traits.

[25] This section draws on MacDonald (2017, 2019).

Table 3
Agricultural sales of six largest firms in the global seed and pesticide industry in 2015

Company	Country	2015 global sales in U.S. dollars (millions)			Merger partner
		Seeds and traits	Agricultural chemicals	Total agricultural sales	
Monsanto	United States	10,243	4,758	15,001	Bayer
Syngenta	Switzerland	2,838	10,005	12,843	ChemChina
Bayer	Germany	1,416	9,173	10,589	Monsanto
DuPont	United States	6,785	3,013	9,798	Dow
BASF	Germany	Small[1]	6,455	6,455	None
Dow Chemical	United States	1,409	4,977	6,386	DuPont
Combined sales		**22,691**	**38,381**	**61,072**	

[1] BASF had a limited amount of seed and trait sales in 2015 and did not report them separately.

Source: USDA, Economic Research Service using data from company annual financial reports.

In December 2015, Dow Chemical and DuPont proposed to merge. Two months later, in February 2016, the State-owned Chinese company China National Chemical Corporation (known as ChemChina) offered $43 billion to purchase Syngenta. Finally, in September 2016, Bayer proposed to acquire Monsanto for $66 billion. Hence, five of the six major global seed and chemical firms were parties to the proposed mergers, with only BASF excepted (although BASF was later a party to an antitrust settlement remedy).

Each firm had a distinctive profile, with a strong tilt toward either seeds and traits or chemicals. For example, seeds and traits accounted for about 70 percent of agricultural product sales at DuPont and Monsanto, while Dow Chemical and Bayer derived nearly 80 percent of their agricultural sales from chemicals. Syngenta, meanwhile, was the largest producer of agricultural chemicals among the Big Six and was the third-largest seed business. BASF, which was not initially involved in the mergers, had the third-largest agricultural chemical business among the Big Six but did not have a significant seed business.

ChemChina was the largest producer of agrichemicals in China, and through its ownership of the Israeli firm Adama, produced generic pesticide products for sale in the United States and other countries. However, in contrast to the Big Six, ChemChina did not invest heavily in R&D for new products and did not participate in the seed business.

Concerns Regarding Competition in Pricing and Innovation

Each of the merging firms had a global presence, with a wide variety of products sold in multiple countries. Many of the specific seed and chemical markets where these firms operated were already highly concentrated, and the mergers would reduce the number of competitors in some of these markets. The proposed mergers were subject to review by antitrust enforcement agencies in the United States and the European Union (EU)—the two largest markets for their products—as well as by agencies in Australia, Brazil, Canada, China, India, and South Africa. Those reviews focused on the likely effects of the mergers in those concentrated markets (table 4).

Table 4
U.S. antitrust agencies focused on competition in markets for these seed and chemical products

ChemChina's acquisition of Syngenta (announced February 2016; completed July 2017; Syngenta Group formed November 2020)
▪ Paraquat, a herbicide used primarily to clear fields prior to planting ▪ Abamectin, an insecticide used primarily in citrus and tree nut crops ▪ Chlorothalonil, a fungicide used primarily in peanut and potato crops
Dow Chemical-DuPont merger (announced December 2015; completed August 2017; Corteva spun off June 2019)
▪ Broadleaf herbicides for winter wheat ▪ Insecticides for chewing pests
Bayer-Monsanto merger (announced September 2016; completed June 2018)
▪ Canola: GM (genetically modified) seeds; traits for herbicide-tolerance ▪ Corn: GM seeds ▪ Cotton: GM seeds; traits for herbicide-tolerance and insect-resistance ▪ Soybeans: GM seeds; traits for herbicide-tolerance ▪ Vegetables: carrot, cucumber, onion, tomato, and watermelon seeds ▪ Foundational herbicides ▪ Nematicide seed treatments in corn, cotton, and soybeans ▪ Digital platforms

Source: USDA, Economic Research Service using complaints filed in *United States* v. *Bayer AG and Monsanto Company*; *United States, State of Iowa, State of Mississippi, State of Montana* v. *Dow Chemical Company and E.I. DuPont de Nemours and Company;* and United States before the Federal Trade Commission in the Matter of China National Chemical Corporation.

Proponents of the mergers argued that firms needed greater scale to invest in and support research, and that the mergers—by creating more balanced portfolios of seed and chemical businesses—would spur greater combined seed/chemical innovations. Opponents argued that with less competition it would be in the interests of the combined firms to raise product prices and to be less likely to invest in research and innovation once the spur of rivalry was removed.

Antitrust agencies evaluated these claims and assessed the likely competitive impacts of the mergers. Authorities in the United States, the EU, and Brazil pursued structural remedies—approving the mergers only after sales of assets to other seed and chemical providers.

The 2015–20 Round of Mergers: What Happened

The ChemChina Acquisition of Syngenta

The FTC and the DOJ share responsibility for merger enforcement in the United States, and they sort cases according to each agency's experience and expertise in the key products at issue. Since ChemChina did not produce crop seeds, the acquisition had no effect on competition in the markets in which Syngenta sold seeds (and where the DOJ maintains expertise). The review was therefore completed by the FTC and focused on three pesticide markets:

- Paraquat, a nonselective herbicide used to clear fields prior to the growing season;
- Abamectin, an insecticide used to kill mites, psyllids, and leafminers, primarily in citrus and tree nut crops; and
- Chlorothalonil, a broad-spectrum fungicide used primarily in peanut and potato crops.

Syngenta was the market leader in each product, while ChemChina's Adama subsidiary was the largest or second-largest producer of generic versions of the products. The FTC alleged that the combined firm would account for 60 percent of paraquat sales, 80 percent of abamectin sales, and 40 percent of chlorothalonil sales—and that the increase in concentration would reduce competition sufficiently to allow the remaining firms to raise prices.

The FTC approved the merger subject to the divestiture of the ChemChina products in the markets of concern. The three pesticide businesses were then sold to American Vanguard, a California-based producer of crop protection products. European authorities also approved the acquisition, subject to the divestiture of certain other pesticide lines sold in Europe.

The Dow Chemical-DuPont Merger

The DOJ reviewed the Dow Chemical-DuPont merger and expressed concerns with the likely competitive impact of the merger in two herbicide markets. DuPont produced the largest selling herbicide for control of broadleaf weeds in winter wheat, while Dow Chemical had recently introduced a competing product. The second market reviewed by the DOJ for possible impacts of the merger was of insecticides used to control chewing pests such as moth larvae and beetles, which are of particular concern in specialty crops. Dow Chemical and DuPont were the two largest sellers of insecticides for chewing pests.

The DOJ complaint alleged that the combined firm would control 40 percent of market sales in broadleaf herbicides for winter wheat and 75 percent of the market for insecticides targeted at chewing pests, enough to allow the firm to raise prices. In addition, the DOJ argued that the competitive rivalry between Dow Chemical and DuPont had led to the development and introduction of new and improved products in each market and that a merger would eliminate that rivalry along with the competitive pressures to introduce new products. The European Commission (which enforces EU competition rules) expressed similar competitive concerns, as well as concerns regarding herbicides for cereals, certain oilseeds, and rice.

As a condition of obtaining approval in the United States and the EU, DuPont divested parts of the firm's pesticide business, including R&D assets, in a sale to FMC Corporation, a diversified U.S.-based manufacturer of pesticides and lithium products. Separately, Dow Chemical agreed to divest certain nonagricultural chemical businesses to meet competitive concerns in those markets.

Brazilian authorities also expressed competitive concerns regarding the corn seed market in Brazil, where the two companies competed. The authorities approved the merger only after the divestiture of Dow Chemical's corn seed business in Brazil, which was sold to CITIC Agri Fund, a division of the Chinese State-backed firm CITIC, Ltd. After addressing objections from the various enforcement agencies, Dow Chemical and DuPont completed their merger, and the combined remaining agricultural businesses of the two firms were spun off, as originally planned, into a new specialized firm called Corteva.

Bayer's Acquisition of Monsanto

In the United States, the DOJ identified several areas of concern about this merger. For example, the firms were the two leading suppliers of GM cotton seeds; each firm also produced GM traits for herbicide tolerance and insect resistance used in their own seeds and licensed to other seed firms. The two firms accounted for almost all of the herbicide-tolerant and insect-resistant traits in GM cotton seeds. Similarly, they were the two major suppliers of GM canola seeds and also of the herbicide-tolerant traits found in their own and other firms' GM canola seeds.

Soybeans were another concern. Monsanto had been the market leader in GM soybeans since the mid-1990s. The firm was the largest seller of seeds and the only provider of herbicide-tolerant traits (other firms licensed the trait from Monsanto). The traits conferred tolerance to glyphosate, a broad-spectrum herbicide marketed by Monsanto under the trade name Roundup. However, in the decade prior to the announced merger Bayer had developed a soybean seed business based on traits conferring tolerance to another broad-spectrum herbicide, glufosinate, marketed by Bayer under the trade name Liberty, and had begun to expand its soybean seed and trait businesses at Monsanto's expense.

The DOJ also expressed concern about the effects of the merger in U.S. markets for seed treatments. Bayer and Monsanto competed head-to-head in markets for nematicide seed treatments in corn, cotton, and soybeans, so the merger would remove a competitor in a highly concentrated market. Bayer also sold another critical seed treatment product, called Poncho, to Monsanto and other corn seed producers. Poncho is the only effective seed treatment for protection against corn rootworms, and a seed treated with Poncho is more valuable where there are rootworm infestations. While Bayer did not sell corn seeds, the DOJ argued that the merger would nonetheless affect competition in corn seed markets. A combined Monsanto-Bayer would have the incentive to charge higher prices for Poncho to other corn seed producers or to deny them access to the treatment entirely, thereby foreclosing competition for Monsanto's corn seed business.

Finally, the DOJ cited concerns with U.S. markets for five vegetable seeds—carrots, cucumbers, onions, tomatoes, and watermelons. Each market was highly concentrated, with only a few sellers; each had made significant improvements in seed varieties through conventional breeding programs; and Bayer and Monsanto were leading suppliers in each market.

To address the enforcement agencies' concerns about the proposed transaction, Bayer divested substantial assets. Specifically, BASF acquired all of Bayer's soybean, canola, and vegetable seed businesses and all of its U.S. cotton seed business, as well as Bayer's R&D capabilities for the divested crops, for hybrid wheat, and for its LibertyLink trait technology for herbicide-tolerant seeds. BASF also acquired several Bayer herbicide businesses, some Bayer seed treatment products, and Bayer's digital farming business, which develops comprehensive field-level information on soil attributes, weather, and seed, as well as chemical performance to support precision agriculture technologies and farmer decision making. The merger between Bayer and Monsanto was completed in June 2018.

In each of these cases, the DOJ alleged that, with the elimination of a competitor, the remaining firms in the market would be able to raise prices while losing few sales to rival sellers or products. Moreover, as in the Dow Chemical–DuPont case, the DOJ further alleged that rivalry among the firms had provided competitive pressures to research, develop, and market new seed and crop protection products. With a rival removed through the merger, the DOJ argued that firms would have less competitive pressure to develop new products and that innovation and productivity growth would suffer as a result.

As of 2021, ChemChina and Bayer had become the world leaders in agricultural chemicals, while Bayer and Corteva held the leading positions in the crop seeds and traits business (table 5). In June 2020, ChemChina announced the formation of its Syngenta Group subsidiary, which in addition to Syngenta and Adama also brought in the agricultural businesses from another large State-owned Chinese chemical company, Sinochem. Only one of the firms, Corteva, remained a U.S.-based company.

Table 5
Agricultural sales in 2021 of the four seed-chemical firms that resulted from 2015–20 mergers

		2021 global sales in U.S. dollars (millions)			
Company	Country	Seeds and traits	Agricultural chemicals	Total agricultural sales	Merger partner
Bayer	Germany	11,162	11,438	22,600	Monsanto
ChemChina's Syngenta Group	China	3,563	13,170	16,733	Syngenta, Adama, and agricultural businesses of Sinochem
Corteva	United States	8,402	7,253	15,655	DuPont-Dow Chemical
BASF	Germany	1,971	7,714	9,685	Bayer seed business
Combined sales		**25,098**	**39,575**	**64,673**	

Source: USDA, Economic Research Service, using data from company annual financial reports.

Competition Issues Raised in the Merger Cases

The competitive concerns identified for these mergers (and discussed above) focused on two broad issues: (1) reduced competition in certain highly concentrated seed, seed trait, pesticide, and seed treatment markets, leading to higher prices charged to farmers, and (2) competition in research and innovation in those markets, and whether mergers would lead to reduced R&D expenditures and less innovation in the future.

Antitrust enforcement agencies obtained structural remedies from the two firms (divestitures of assets to other firms) for the competitive problems that the agencies had identified in the mergers. In principle, a divestiture allows the merging firms to realize the potential efficiencies and synergies from a merger while limiting the merger's risks to competition. A successful divestiture remedy depends on finding a firm with the capacity to take on and manage the divested business.

As a result of the divestitures, BASF became an important competitor in crop seeds (competing against Bayer, ChemChina/Syngenta, and Corteva), while FMC became the fifth-largest producer of pesticides in the United States. Each firm also has significant research capacity to support its products. The impact of the DOJ and European Commission decisions in these cases, and the value of structural remedies more generally, will depend on how well these new entrants compete in these product markets.

The DOJ investigations of the Dow Chemical-DuPont and Bayer-Monsanto transactions focused heavily on the likely impact of the mergers on innovation, and particularly on the argument that removal of a rival in a highly concentrated market would lead to reduced research and innovation. Antitrust agencies have focused more heavily on innovation concerns in the last two decades; these concerns have become an important feature in a growing number of cases across the economy and in agribusiness. However, there is not yet much empirical evidence on the effect of competition on research investments and innovation—and, specifically, on how many rivals are necessary to spur innovation. This issue will remain an important question for antitrust policy and economic research.

Conclusions

The dominant driver of structural change in the seed industry has been the application of biotechnology to crop agriculture. A small number of multinational seed-chemical companies now dominate the market for GM seed in the United States and worldwide, while the market for non-GM crop seed remains more diverse. These developments have had considerable impact on the amount of private investment in crop R&D and seed prices, both of which have risen sharply in recent decades, especially for GM seed. Higher seed prices reflect to a large degree the market power that firms derive from their IPRs over new, commercially viable crop varieties and a return on company investment in R&D. Antitrust policy has focused on the effect of mergers on competition in specific seed and chemical product markets. Antitrust investigations assess not only impact on prices but also on innovation—whether a merger might reduce incentives by firms to invest in R&D. In the 2015–20 round of mergers among major seed and agricultural chemical firms, structural remedies to antitrust concerns involved divestiture of certain assets of merging firms to other competitors in the industry.

Consolidation and Competition in Meatpacking

Meatpacking industries were transformed over the last four decades, highlighted by much larger plants and higher market concentration, while livestock production also underwent significant reorganizations. Those developments led to ongoing controversies over competition in these industries.

Market concentration rose sharply over time (table 6). CR4 in hogs nearly doubled between 1980 and 2019, reaching 67 percent in the latter year. Concentration for steers and heifers increased by considerably more, so that CR4 reached 85 percent of slaughter in 2019.[26] While consolidation in hog slaughter proceeded steadily over time, in steers and heifers it was compressed to a strikingly short period, from 1980 to 1995 (MacDonald & Ollinger, 2005). Indeed, these authors knew of no mature American industry that displayed as dramatic a change in concentration in as short a time.

Table 6
Concentration in U.S. cattle, hog, broiler, and turkey procurement

	1980	1995	2010	2019
	Share processed by the four largest processors (CR4)			
Steers and heifers	36	81	85	85
Hogs	34	46	65	67
Broilers	NA	50	51	53
Turkeys	NA	41	56	55

CR4 = four-firm concentration ratio; NA = not available.

Note: The Packers and Stockyards Program did not collect data on poultry plants in the 1980s.

Source: USDA, Agricultural Marketing Service, Packers and Stockyards Program, Annual Reports.

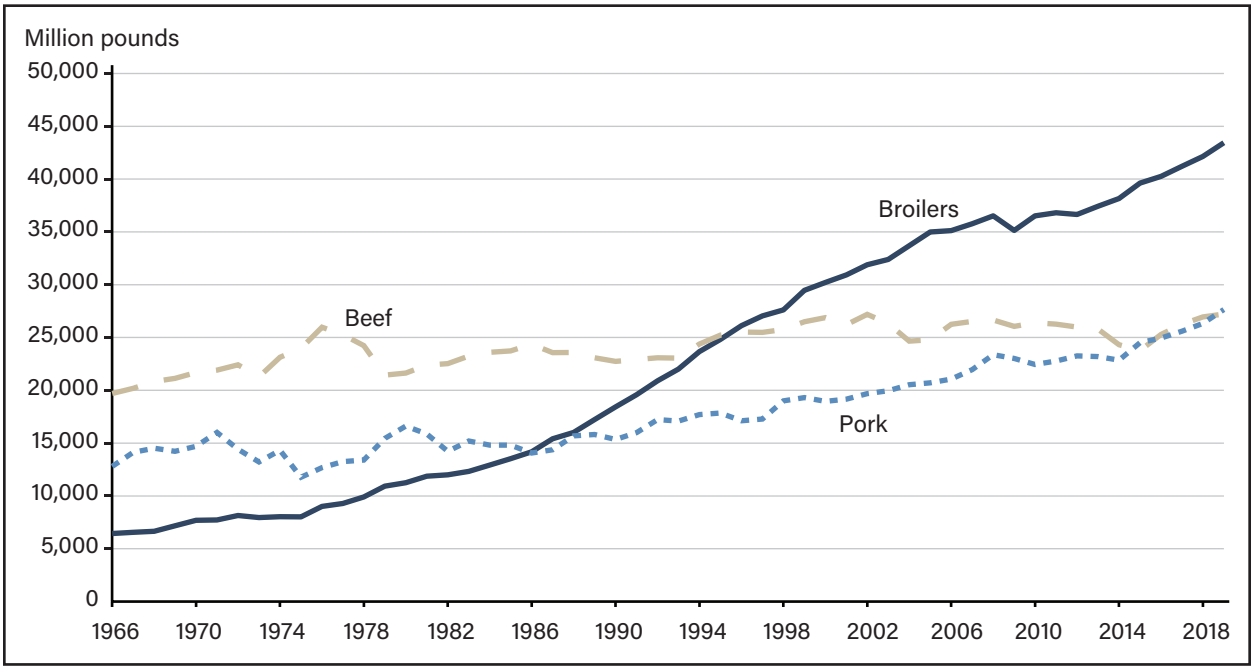
[26] USDA's Packers and Stockyards Program (PSP) reports on two classes of cattle: cows and bulls, and steers and heifers. Plants specialize by class since cows and bulls are often larger animals and yield a different product: lean beef mixed into ground products. Steers and heifers, fed on corn-based rations, provide a more marbled beef product. The broiler and turkey CR4s are based on liveweight pounds, while others are based on the number of head.

Technology enabled scale economies to become a driving force at larger plants; packers found that they could realize economies by processing in larger plants if they could assure themselves of large and steady flows of livestock to those plants (Morrison Paul, 2001b; MacDonald et al., 2000), so they built much larger ones. In 1977, most steer and heifer slaughter occurred in plants handling less than 250,000 head annually, and no plant handled more than 1 million cattle; by 1997, plants handling a million or more cattle accounted for 63 percent of slaughter. Similarly, plants handling at least 1 million hogs accounted for 38 percent of hog slaughter in 1977 but for 88 percent by 1997 (MacDonald et al., 2000). Production similarly shifted to much larger poultry plants during this period (Ollinger et al., 2000).

The packers and processors who built larger plants also reorganized tasks within plants. They added more fabrication tasks, particularly in cattle and poultry plants, thereby shipping fewer whole and half carcasses and more primal cuts, store-ready cuts, and cut-up poultry parts. Packers sharply reduced wages at large cattle and hog plants—likely in anticipation of expanded flows of immigrant labor—thereby removing a cost disadvantage for large plants and facilitating exploitation of their technological advantages. These steps, which supported shifts of production to larger plants, are explored in greater detail in Peel (2021), MacDonald & Ollinger (2005), and Ollinger et al. (2000).

Production shifted to larger plants in all three industries (cattle, hogs, and chickens) after 1980, but the CR4 rose much more in cattle than in hogs and much more in hogs than in chickens. An important part of the reason for this lies in differences in industry growth (figure 6).

Figure 6
Annual beef, broiler, and pork production in the United States, 1966–2018



Source: USDA, Economic Research Service.

Between 1966 and 2019, total U.S. broiler production grew from 6.4 billion pounds (liveweight) to 43.4 billion pounds—growth largely driven by striking increases in per capita consumption, from an annual average of 32 pounds person to 95 pounds over this period. Beef production grew far more slowly as per capita consumption fell from a 1976 peak. Expansions in exports benefited all three industries after 2000, but chicken and pork export growth far outpaced beef.

With production moving to much larger slaughter plants in each industry, the shift could be more easily accommodated without increasing concentration in broilers, which required more plants to meet increasing demand. In beef, slower demand growth meant that a shift to larger plants would force small and midsized plants and firms out of the industry.

Vertical Coordination

Large plants need to maintain large and steady flows of livestock to run their operations efficiently (Morrison Paul, 2001a). As packers built much bigger plants, they also developed close linkages, through direct ownership or contracts, with livestock producers.

The most striking transformation occurred in hog production (McBride & Key, 2013). Until the early 1990's, farmers raised pigs from birth to marketing ("farrow to finish") with feed from the farm's crops and sold market-weight hogs to a packer in a cash market transaction. By the early 2000's, most hogs were raised by farmers under a production contract with an integrator—a firm that coordinates production. The integrator provides young piglets and formulated feed rations, while the farmer provides housing, labor, and management. The new operations specialize in single stages of production, such as farrowing, farrow-to-wean, or wean-to-finish, coordinated by the integrator. There are also substantial scale economies, so hog production now occurs in fewer but much larger farms.

Some packers act as integrators and contract to raise their own hogs. Other large integrators sell hogs to packers under marketing contracts that commit each side to quantity and pricing targets. Less than 10 percent of hogs are now sold through cash markets.

Vertical coordination in chicken production is less complex than with hogs. About 20 large processors contract with farmers to raise chickens for them, with almost all raised under production contracts. The processors operate hatcheries and feed mills and provide farmers with chicks and feed. As with hogs, farmers are paid not for the animals, but for services provided in raising chickens, although specific compensation formulas for chickens differ.[27]

Beef production is less tightly integrated. The Census of Agriculture reports that over 750,000 farms and ranches, widely dispersed across the country, had beef cows in 2017 (compared with 15,000 contract chicken and 8,000 contract hog growers). Once calves born on those "cow-calf" operations are weaned (at about 6 to 8 months of age), they may be retained on the farm or sold to another farm or ranch, where they may continue to be raised on pasture (another 4 to 6 months) in the "stocker" phase of production. When the animals weigh 600–900 pounds, they are moved to confined feedlots for another 4 to 6 months and fed high-concentrate (grain) rations for additional growth and deposition of fat to produce desirable carcasses.

While USDA estimates that there were 27,000 U.S. feedlots in 2020, half of all fed cattle came from just 132 of them, with capacities of at least 32,000 head. Most large feedlots are in the Great Plains near packing plants, and most cattle are sold to packers through marketing contracts that specify a quantity, a delivery window, and a pricing formula. In turn, the formula sets a base price—often linked to a futures or an average reported cash price—with quality adjustments. Feeders may own the cattle but will often feed and market them on behalf of owners who might be cow-calf producers, stockers, or investors.

[27] Hog contract fees are paid per animal space, or per hog delivered, with premiums and discounts applied for targets such as feed conversion. Chicken contract fees also specify premiums and discounts from a base fee per pound, but they reflect the grower's feed conversion and mortality performance, relative to other growers delivering chickens at the same time (MacDonald, 2014).

Mergers and Meatpacking Concentration

There have been many mergers in meat and poultry processing, but contrary to some claims (Goodman, 2021; Salop & Morton, 2021), mergers have had only a modest direct effect on concentration because few have combined rival packers.

Some are interindustry "conglomerate" mergers. Tyson Foods, the largest U.S. broiler processor, acquired IBP, the largest cattle and hog packer, while Perdue Foods, a major broiler processor, acquired Coleman Natural Beef. JBS, a Brazilian meatpacker, acquired the beef packer Swift, the pork packing business of Cargill, and the chicken processor Pilgrim's Pride. As a result of such acquisitions, several large firms operate in multiple meat processing businesses. But since these mergers combine firms from different industries, they don't directly affect market concentration in any one meatpacking industry.

Packers have also made "vertical" acquisitions of firms active in livestock production or processed meats. For example, JBS and Cargill each acquired, and then sold off, cattle feeding businesses. Most large packers have acquired downstream meat processing firms that transform carcasses into ground, breaded, or marinated meat products. Vertical mergers may affect corporate strategy and competition, but do not directly affect concentration since they do not combine packing plants.

"Horizontal" mergers do affect concentration. For example, Smithfield made a series of horizontal acquisitions as it grew to become the largest pork packer, including acquiring its local rival Gwaltney as well as the Midwestern packers John Morrell and Farmland Industries. However, Smithfield also constructed the largest hog packing plant in the country during this period and expanded some of its acquired plants while closing others, so mergers weren't the whole story.

In the early 1980s, Cargill, the second-largest beef packer, purchased Spencer Beef, the third-largest beef packer. However, the change in concentration that resulted from that merger was less than 5 percentage points, a small component of the nearly 50-percentage-point change in CR4 that occurred between 1980 and 1995.

Indeed, MacDonald and Ollinger (2005) found that all acquired beef plants accounted in total for less than 7 percent of production during beef-packing's 1980–95 consolidation. Moreover, the authors showed that plants operated by the 4 largest packers, which had average slaughter volumes of 417,000 head in 1977, were handling an average of 1 million head by 2002. Plant expansion, rather than plant acquisition through mergers, drove increased concentration.

Local Market Concentration

Nationwide concentration measures are widely available and useful for assessing broad changes in industry consolidation. Competition in the sale of wholesale meats occurs in national markets, but the procurement of livestock occurs in local or regional markets because the animals cannot be moved far for slaughter. Those local markets for animals or for contract growers are often more highly concentrated than national markets.

Consider broiler production: Because almost all broilers are raised by growers for integrators, there is no market for the live chickens. Instead, the relevant procurement market is actually a labor market, the market for grower's services, and those markets are local, focused on growers located near processing plants. Ninety percent of contract broilers are raised within 60 miles of the processing plant, while 50 percent are within 30 miles (MacDonald, 2014), and integrators seek growers within those local areas.

Most growers report few integrators in their local area. For example, MacDonald (2014) found that 77 percent of broiler growers faced no more than three potential integrators, and 54 percent faced just one or two, findings that are consistent with other studies covering different years (MacDonald & Key, 2012; FLAG, 2001; Burton et al., 2003). While national broiler CR4 is 53 percent, local grower markets are much more concentrated.

Hog production is also geographically concentrated. Sixty percent of market hogs are raised in the Western Corn Belt (WCB) region of Iowa, southern Minnesota, eastern Nebraska and South Dakota, northern Missouri, and western Illinois. About 13 percent are in the Eastern Corn Belt (ECB) region of Indiana, Michigan, and Ohio, and 11 percent are in North Carolina.[28]

Market hogs move up to 200 miles to packing plants, a wider market area than broilers, and hog producers in the WCB therefore have more packers to sell to: JBS Swift, Smithfield, Tyson Foods, Hormel, Triumph, and Prestage, which all operate plants within the WCB. All 6 of these packing firms source some hogs through contracts with growers, but there are at least 18 other large nonpacker integrators who also operate in the WCB. Nonpacker integrators contract with growers and sell hogs to packers in large volumes through marketing contracts.

Local markets for contract hog growers, and for cash or marketing contract sales of hogs, are much more concentrated in other parts of the country outside of the WCB. One packer, Smithfield, accounts for almost all slaughter in the Southeast (North Carolina, predominantly), and one packer services hog producers in the Oklahoma/Texas panhandles. Four packers compete in the ECB States of Indiana, Michigan, and Ohio.

Unlike broilers and hogs, fed cattle (steers and heifers ready for slaughter) are usually acquired by packers from independent feed lots through cash sales or marketing contracts, and the relevant markets are for cattle rather than for grower services. Nationwide, the CR4 for fed cattle purchases is 85 percent, with an HHI of 1,878. However, fed cattle purchases occur within more highly concentrated regions because of the expense of moving cattle.

For example, USDA calculated HHIs for beef packer concentration in nine U.S. regions (States combined) or individual States in 1996: Nebraska; Texas; Kansas; Colorado; Arizona and California; Idaho, Washington, and Utah; Iowa and Illinois; Wisconsin and Minnesota; and Pennsylvania (GIPSA, 1996). One region had a single buyer (an HHI of 10,000), while seven regions or States had HHI measures between 3,000 and 5,500—much higher than the national HHI.

The DOJ constructed regional HHI measures in 2008 as part of a merger case.[29] The agency argued that Arizona/California was a relevant regional cattle market, and that the High Plains (eastern Colorado, Texas, Oklahoma, Kansas, Nebraska, and western Iowa) constituted another market. The pre-merger HHI in Arizona/California was 3,200 and would rise to 6,000 with a merger. In the High Plains, where 80 percent of fed cattle are raised, the pre-merger HHI was 2,100, nearly 20 percent higher than the national HHI, and would rise to 2,600 after a merger. Regional markets are considerably more concentrated than national estimates imply.

[28] According to USDA's National Agricultural Statistics Service *Meat Animals Production, Distribution, and Income*.

[29] The case was the proposed merger of the nation's third- and fourth-largest packers, JBS Swift and National Beef Packing, which the DOJ opposed on competitive grounds.

Competition and Concentration in Livestock and Poultry: What We Knew by 2010

Meatpacking competition, particularly in markets for livestock, has attracted a great deal of research and policy attention over the years. Economic research that analyzed market data between 1980 and 2010 generally found meatpacking to be competitive, but recent evidence provides reason to revisit that conclusion, and this report will summarize research and data before and after 2010.

While many pricing studies (summarized below) analyze cattle markets, few study broilers or hogs. Fees paid to contract broiler growers do appear to be lower in more highly concentrated local markets. MacDonald and Key (2012), using data from a large representative survey of growers, assessed those fees in an analysis that accounted for differences in bird types and facility attributes. Compared with markets with four or more integrators, growers facing two integrators received fees that were 3 to 4 percent lower, while those facing a single integrator were paid 7 to 8 percent less for their services.

As the hog industry's dramatic series of changes between 1990 and 2010 led to much larger packing plants, farm production also shifted toward much larger and more specialized farms integrated into networks through production contracts. These changes led to large gains in farm-level productivity from 1994 to 2010. From 1980 to 2000, there were also notable improvements in productivity at meat packing plants (McBride & Key, 2013; Davis et al., 2022; MacDonald et al., 2000). In turn, productivity improvements led to reductions in production costs and lower pork prices, which ensured that the United States became a large net exporter of pork.

Recent research in the hog industry has focused on its transformation, with little recent work on competition and pricing in markets for live hogs and none on competition in markets for contract growers. Zheng and Vukina (2009) did analyze prices paid for hogs in spot and marketing contract sales during 2001–07. They found some evidence of market power in live hog procurement, but those effects were small: prices paid for live hogs were 1.1 percent lower than competitive prices would have been.

Economists have published many analyses of concentration and monopsony power in cattle, based on research spurred by the rapid consolidation of beef-packing in the 1980s and 1990s and research support provided through the USDA. In particular, the Packers and Stockyards Division (previously the Grain Inspection, Packers and Stockyards Administration, or GIPSA) of the USDA, Agricultural Marketing Service (AMS) used appropriations from Congress to support two large projects with multiple studies on competition based on plant- and transaction-level data: "Concentration in the Red Meat Packing Industry," published in 1996 (GIPSA, 1996), and the "Livestock and Meat Marketing Study," published in 2007 (GIPSA, 2007). The projects led to peer-reviewed journal articles published by the researchers active in the projects.

The large outpouring of research spurred three summaries, by Ward (2002), the U.S. Government Accountability Office (2009), and Wohlgenant (2013). The research covered in those summaries appeared between 1985 and 2010, with data from 1975 through 2005, during and just after the period of rapid consolidation in the meatpacking industry.

The summaries reached two major conclusions. The first concerned the evidence for market power (monopsony) in the form of prices paid for cattle that fell below what would be paid in competitive markets. The two later summaries (GAO, 2009; Wohlgenant, 2013) cite the earlier (Ward, 2002) conclusion and express agreement with it: The research findings in this period find limited market power in beef- and hog-packing. Specifically, some research found that prices matched competitive prices (no market power), while most research found a small amount of market power, with prices falling 1–4 percent below competitive levels.

The second conclusion focused on the effects of industry consolidation on processing costs. The summaries emphasized that economies of scale were important; by building larger plants, firms could realize lower costs

per pound of beef produced. With declining per-capita beef consumption, a shift to larger plants meant fewer plants and increased concentration as smaller, higher-cost plants closed. But the shift to larger plants also reduced processing costs, which lowered beef prices. Lower retail beef prices encouraged increased beef consumption and therefore increased cattle demand, driving higher prices for cattle. The summaries each point out that the impact of lower processing costs on cattle prices likely outweighed the effect of less competition in the industry.[30]

The findings raised an important question at the time, one that persists today. Beef-packing in particular is highly concentrated. So, in that case, why don't packers exercise greater market power? The summaries point to another element of increasing returns to scale as an important reason: Existing plants have substantial fixed costs, so average processing costs per steer rise rapidly as production falls below capacity (Morrison Paul, 2001a). As long as plants run below capacity, individual firms and plants have strong incentives to bid aggressively for cattle. Another way to put it is that packers need to maintain close cooperation to refrain from competing, and for most of the period before 2010, were unable to do so.

In summary, studies of cattle pricing before 2010 found limited evidence of market power in markets for cattle and for meat. Those studies further found that the industry's striking consolidation into larger plants reduced costs and consumer prices, while increasing cattle demand.

Competition and Concentration in Livestock and Poultry: What's New Since 2010

Beef-packing concentration has changed very little since the dramatic consolidation of 1980–95. However, there are three reasons to suspect that something may have changed to allow beef-packers to exert market power: trends in price spreads, changes in industry production capacity, and new entry into meatpacking. In addition, a series of collusion allegations and antitrust lawsuits, largely but not entirely focused on poultry, suggest that some processors may have been collectively exercising market power since 2010.

Trends in Price Spreads

USDA's ERS produces a monthly series on "Choice Beef Price Spreads," including a farm-to-wholesale spread (the difference between the wholesale and farm values) and a wholesale-to-retail spread (the difference between the retail and wholesale values).[31] The wholesale-to-retail spread encompasses transportation, wholesaling, and retailing costs and profits. The farm-to-wholesale spread encompasses packer costs and profits and is a useful indicator for studies of cattle pricing.

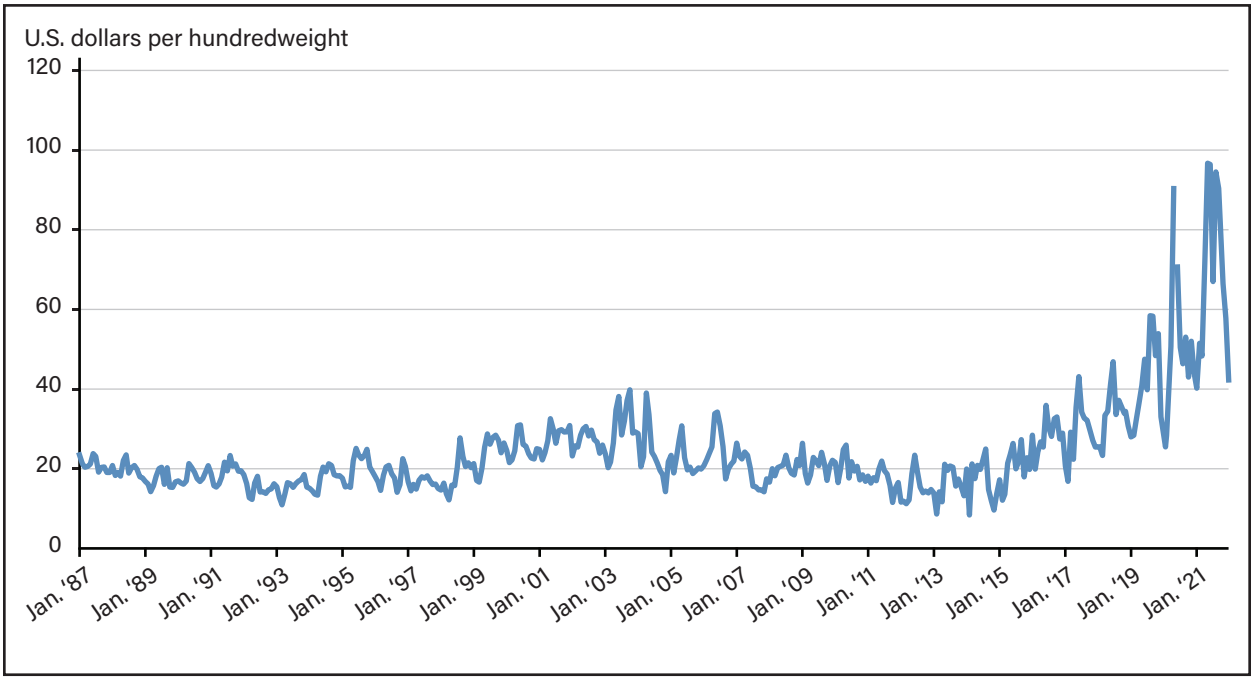
The farm-to-wholesale spread shows sharp fluctuations over time, but only modest trend changes before 2015 (figure 7). The spread declined over 1987–97 despite large increases in concentration, a pattern consistent with research findings that consolidation had little effect on price spreads in the period. The spread then widened in the late 1990s, reflecting increased industry costs associated with expanded food safety controls and the exhaustion of productivity gains from consolidation before falling again through 2012.[32]

[30] It's not uncommon to find that increases in concentration, when arising from the exploitation of scale economies or new innovations, are associated with increasing productivity and falling downstream prices (Ganapati, 2021; Peltzman, 2022).

[31] USDA's ERS collects average prices paid for specified animals (a specific size, graded Choice) at the feedlot; assuming that the animal is cut up into a specified set of beef cuts and byproducts, the agency estimates wholesale and retail values for the animal by using USDA- and BLS-reported prices for those cuts and byproducts (Hahn, 2004). See also Schroeder et al. (2019) for a review of the series and the methods used to construct it.

[32] We adjust the spread for inflation, which increases packer costs for labor, energy, packaging materials, and equipment, with the Producer Price Index (PPI). This adjustment is not ideal, since the PPI doesn't necessarily reflect inflation in the items that packers actually buy. However, inflation adjustments make no difference to the major point, which is that the spread rose sharply after 2015, after showing little trend change in earlier years.

Figure 7
Farm-to-wholesale choice beef spreads, 1987–2021



Note: U.S. dollars are adjusted to 1987 levels with the Producer Price Index.

Source: USDA, Economic Research Service.

A striking new development occurred around 2015: on average, the spread doubled between 2015 and 2019.[33] While hourly production worker wages in meatpacking rose by about 16 percent between 2015 and 2019, the increase in the farm-to-wholesale spread far exceeded the impact of labor costs. In short, price spreads increased substantially after 2015, after displaying no strong trend over the previous 30 years.

Research by the U.S. Government Accountability Office (GAO) supports the suggestion that rising price spreads could be due to (local) market concentration. The GAO's 2018 report (GAO, 2018) analyzed the sources of differences in prices paid for fed cattle during 2013–16, updating a model used in the 1996 Packers and Stockyards Program report noted above. Some results were consistent with earlier research: Higher-quality cattle fetched higher prices, and more uniform lots of cattle also realized higher prices; larger feedlots obtained higher prices, and larger plants paid more. But the research also found a noticeably stronger impact of local market concentration on cattle prices: Prices paid in a county with a relatively high level of concentration (the 75th percentile) were 9 percent lower than in a county with a relatively low concentration of cattle sales (the 25th percentile). This is a substantially larger impact of market concentration than that found in studies of transactions in the 1980s and 1990s.

Changes in Industry Production Capacity

With slow or stagnant growth in the demand for beef, many plants in the 1980s and 1990s ran at less than full capacity much of the time. This insight led to research analyses, initiated by in Crespi et al. (2010), that focused on the idea that monopsony power might vary with the cattle cycle. In an analysis of data from 1988 through 2006, those authors found that markdowns (reductions in cattle price due to monopsony) increased

[33] The wide fluctuations later in the period reflect several dramatic events, including a fire that shut the nation's largest packing plant for months and the COVID epidemic that shut several packing plants. But note that the sharp increase in the spread occurred before those events.

when cattle supplies were ample (and plant capacities were tight). In contrast to earlier studies, they found much larger estimated markdowns when capacities were tight—20 percent, compared with a range of 0–4 percent for studies that only looked at average effects over the same period. In brief, packers bid more aggressively for cattle when plants were running below capacity and forced steep discounts on purchased cattle when plants were fully or near-fully occupied.

Several plants closed during the 2000s, and those closures, combined with a modest cyclical expansion in cattle production, resulted in the first shortage of cattle-packing capacity in 35 years (Peel, 2021), causing plants to add more operating shifts. In Congressional testimony, the cattle analyst Dustin Aherin estimated that by 2021, the industry's cattle-processing capacity stood at 100,000 head per day, down 14,000 head from the early 2000s (Aherin, 2021). With reduced capacity, packers have weaker incentives to bid aggressively for cattle, leading to lower prices for cattle and higher packer margins.

New Entry Into Meatpacking

Several firms have built new meat and poultry slaughter plants in recent years, while others have plans to enter the market. New entry is an indication of economic profits in meatpacking and dissatisfaction with meatpacker performance by retailers and feeders in the supply chain; it is also a solution to high economic profits (as entry should expand capacity and increase competition).

Table 7 lists entrants in all three industries, with a noticeable feature: the new entrants are all associated with organizations of livestock producers or with retailers. The first, Lincoln Premium Poultry, is a joint venture with Costco, the large food retailer, which sought to better control its supply chain for rotisserie chickens. The firm constructed a large and entirely new broiler production and processing complex in Nebraska, handling 2 million birds per week.

Table 7
Recent entrants in the U.S. meatpacking industry

Species and firm	Location	Year of entry	Size
Broilers			
Lincoln Premium Poultry	NE	2020	400,000 head/day
Hogs			
Triumph Foods	IA	2017	20,000 head/day
Prestage Farms	IA	2020	10,000 head/day
Clemens Food Group	MI	2017	10,000 head/day
Cattle			
Sustainable Beef	NE	2023P	1,500 head/day
Cattleman's Heritage	IA	2023P	1,500 head/day
True West Beef	ID	2022P	500 head/day
Intermountain	ID	2022	500 head/day
Missouri Prime	MO	2021	500 head/day

IA = Iowa; ID = Idaho; MI = Michigan; MO = Missouri; NE = Nebraska. P = projected.

Source: USDA, Economic Research Service calculations, from reports in trade magazines.

The three recent entrants into pork packing are all tied to hog producers. Triumph Foods is a joint venture between a packer (Seaboard) and two cooperatives of hog integrators that provide capital and commitments of hogs. Triumph began in 2007 with a plant in Missouri and added a South Dakota plant in 2017. The Clemens Food Group entry follows a similar model: a joint venture between an existing packer and a cooperative of hog integrators in Michigan and Ohio. Finally, Prestage is a large hog integrator that recently entered packing. The three plants are all large enough to realize scale economies in packing, and together add about 8 percent to industry capacity, a significant addition.

New beef-packing entrants—most are planned, and not yet in production—are also tied to cattle producers. Two entrants (Cattlemen's Heritage and Sustainable Beef) are building new facilities in Iowa and Nebraska, while two more plants are planned for Idaho, farther from the major packing plants. A fifth plant has recently gone into operation in a converted and expanded former hog facility in Missouri. Each facility is supported by cooperatives of ranchers and cattle feeders who, as in the hog example, are contributing capital and livestock commitments. In some cases, the plants are also planning to produce branded, high-value beef products aimed at specific consumer segments.

These 5 beef-packing facilities together add the capacity to handle 4,500 cattle per day, equivalent to 1 large packing plant. In an industry in which a dozen large plants account for over half of steer and heifer slaughter, the added capacity could affect competition and prices. But it also points out a risk for the entrants—all five plants are relatively small and are unlikely to realize all available economies of scale in beef-packing.

New entrants are not the only sources of added beef-packing capacity. Two of the four largest packers—National Beef and JBS—announced plans to expand existing plants by an added 2,150 head per day, although National Beef later paused its plans in June 2022. Finally, Walmart, the largest U.S. food retailer, entered a joint venture with a Texas cattle feeder to produce beef to be marketed under a Walmart Black Angus brand. Walmart has built a plant in Georgia to process beef carcasses into retail cuts, and the partners use a midsize Kansas packer (Creekstone Farms) to slaughter the cattle. Thus far, the venture has not added to packing capacity, but may lead to expansions in the future.

Allegations of Collusion in Poultry

Broiler processors have been the subject of four different allegations of collusion to manipulate prices. First, news articles published in 2016 described efforts by processors to manipulate the "Georgia Dock" price, a wholesale chicken price index produced by the Georgia Department of Agriculture and based on processor reporting, which was used in sales negotiations between processors and retail buyers.[34] Second, food retailers filed private antitrust lawsuits against most leading chicken processors, alleging that the firms shared production and financial information—gathered by an industry statistics firm called Agristats, Inc.—to facilitate collusion in chicken production, wholesale chicken prices, and grower fees.[35] Third, the DOJ filed a criminal antitrust suit in 2020, alleging a conspiracy among processors to fix prices for chicken sold to fast-food chains.[36] Finally, the DOJ filed a complaint in July 2022, alleging that several processors shared information on labor compensation at their processing plants to limit competition and wages for plant workers.[37]

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[34] From Peter Whoriskey's "If You Thought You Were Paying Fair Prices for Chicken at the Supermarket, Think Again," *Washington Post*, November 17, 2016; and Spencer Jakab's "Are Food Companies Playing Chicken with Prices?" *Wall Street Journal*, January 18, 2016.

[35] Separate private lawsuits were combined into a single class-action proceeding, *In re Broiler Chicken Litigation*, United States District Court for the Northern District of Illinois, Case No. 16-08637. See also Christopher Leonard's "Is the Chicken Industry Rigged?" *Bloomberg Business Week*, February 15, 2017.

[36] *United States v. Pilgrim's Pride Corporation*. United States District Court for the District of Colorado.

[37] *United States v. Cargill Meat Solutions Corporation et al*. United States District Court for the District of Maryland.

The first allegation resulted in the suspension of the Georgia Dock Price, while the second has so far resulted in a series of settlements between complainants and some processors, with other parts of the case continuing. DOJ obtained a settlement with the Pilgrim's Pride Corporation in the third case, but individual defendants were acquitted in jury trials. Finally, the fourth case resulted in a consent decree among DOJ, Cargill, Wayne Farms, and Sanderson Farms, in which the processors agreed to stop sharing wage information.

The cases primarily concern chicken processors, although some of the allegations in the second set of cases (the sharing of production and financial information) also refer to pork and beef processors. They cover a range of distinctly different actions and raise important questions about the intensity of competition in the industry since 2010.

Mergers and Merger Policy in Meat and Poultry Processing

Several mergers in meat and poultry processing illustrate the role that competition and concentration play in policy. The first concerns the 1983 acquisition by Cargill, the second-largest U.S. beef-packer, of Spencer Foods, then the third-largest packer. The DOJ did not oppose the merger, but Monfort (the fifth-largest packer at the time) advanced a private antitrust suit to stop the merger. That case ultimately went to the U.S. Supreme Court, which allowed the merger to proceed in a 1986 decision.[38]

According to the District Court, fed cattle CR4 in the High Plains region stood at 52 percent in 1983 and would increase to 57.5 percent with the merger. Thus, concentration in the region, while rising, was not very high according to the DOJ's merger guidelines, and therefore not as problematic as later merger cases would be.

In 2007, the Brazilian meatpacking firm JBS acquired Swift, the third-largest U.S. beef-packer. The next year, JBS announced plans to acquire the beef-packing unit of Smithfield Foods and National Beef, which was the fourth-largest U.S. beef-packer. The DOJ opposed the acquisition of National Beef but did not oppose either of the other mergers. JBS then dropped the proposed acquisition of National Beef.

What distinguishes these cases? With regard to the purchase of Swift, JBS at that time was not active in the U.S. market, so the purchase would change the ownership of Swift without altering concentration in the industry—the merger was unlikely to reduce competition.

Smithfield operated a cattle slaughter plant in the Southwest, a highly concentrated region where it competed with a National Beef plant, but the two plants would continue to compete as long as JBS did not also acquire National Beef.[39] In contrast, the National Beef acquisition would combine two of the four major competitors in a highly concentrated market and raise concentration noticeably in fed cattle procurement markets in the Southwest and the High Plains. While research at the time found that markets for fed cattle were competitive, the DOJ argued that further concentration could tip markets toward monopsony.

[38] Monfort argued that Cargill and IBP, the largest packer, would increase cattle prices after the merger, thus disadvantaging Monfort. The Supreme Court decision asserted that this would be evidence of competition, which was what antitrust was designed to promote (*Cargill v. Monfort*, 479 U.S. 104).

[39] A complicating factor, in the Smithfield case, concerned the types of cattle that Smithfield slaughtered. Their plants primarily handled dairy cows, which are a separate market from fed cattle (steers and heifers). However, the Smithfield plants did also slaughter some beef breeds and some fed dairy breeds, and hence provided some competition in fed cattle markets.

In 2011, Tyson Foods sold a Shenandoah Valley broiler processing plant and production complex to George's Foods. At the time, there were three integrators in the Valley—Tyson, George's, and Pilgrim's Pride—so the transaction would reduce the number of competing integrators from three to two. Since there's evidence that contract fees paid to growers are affected by the number of integrators competing in a local market, the proposed merger could affect grower fees.

The DOJ reached a settlement with George's later in 2011. The sale would proceed on the condition that George's would agree to invest in the Tyson plant and expand its capacity. With a larger plant, George's would have stronger incentives to find more growers and pay the higher fees necessary to get them and run the plant efficiently. The theory behind the settlement aligns with discussions above concerning competition and plant capacity.

Conclusions

Meat and poultry processing industries were transformed as packers built large plants to achieve economies of scale. Processors also formed tighter linkages with a reorganized livestock production sector to assure a dependable supply of livestock to keep plants at near-full capacity. Those transformations led to striking increases in concentration, particularly in slow-growing pork and beef industries, while also leading to lower costs in livestock production and slaughter. However, while there were some significant mergers among processors, much of the growth in concentration came about from the construction of new, or the expansion of, existing plants by the large processors, rather than from mergers among rivals.

Despite high levels of concentration, studies of cattle market pricing prior to 2010 found limited evidence of packer market power. Lower processing costs appeared to be largely passed to consumers, and the resulting increased demand for beef in turn led to higher cattle demand and prices. There have been fewer studies of poultry or pork markets, but those studies found only small or local effects from concentration on prices in those industries.

However, developments since 2010, which show rising spreads between processor prices paid for livestock and received for meat, as well as new entrants to the industry, suggest that meatpackers now have been able to exercise greater market power over livestock prices than in earlier decades. New entry, and plant expansion among incumbent producers, will determine whether such market power can be maintained.

Concentration and Competition in Food Retail

Food retail concentration has been growing, with nationwide CR4 rising from 13 percent in 1990 to 34 percent by 2019, and HHI rising from 106 in 1990 to 593 by 2019 (Zeballos et al., 2023).[40] [41] In turn, the increase was accompanied by a striking industry transformation over the last three decades.

Since the development of the traditional supermarket format in the 1930s, most food retail sales have occurred at supermarkets. However, nontraditional food retail formats started to enter into the food retail space in the 1980s. These nontraditional stores include supercenters (large discount department stores that also sell food products), warehouse club stores (limited-service general merchandise stores that often sell

[40] The focus here is on retail businesses, such as supermarkets and grocery stores, that sell food for consumption at home.

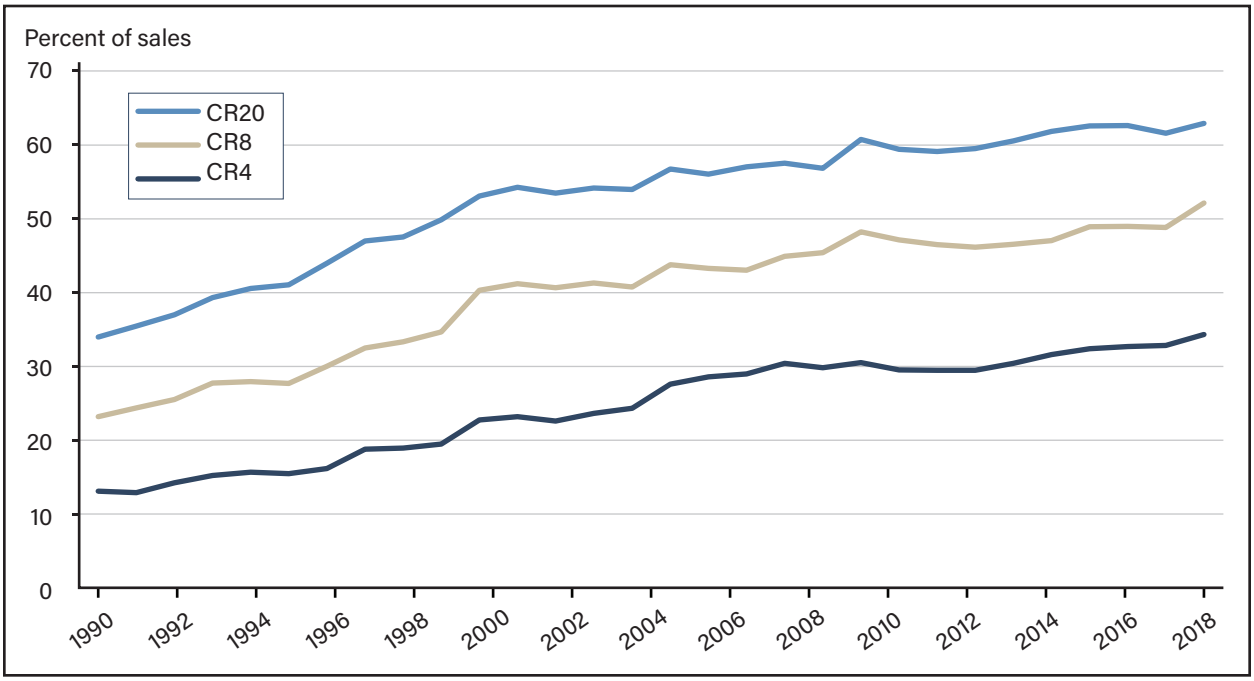
[41] Although food retail competition is more localized, national concentration statistics provide important insights for pricing and buyer power, as we discuss later.

large and packaged food products), dollar stores, convenience stores, and even online retail. These new store formats—often part of large national chains—have expanded their presence in food retail, with the number of supercenters expanding from 705 stores in 1996 to 2,659 in 2006 (Ellickson, 2016). In particular, Walmart held a small share of food sales in the early 1990s, but the chain has now emerged as the largest food retailer in the United States. As the newer formats expanded, the supermarket sector contracted from 29,742 stores and 80 percent of food retail sales in 1999 to 27,201 stores and 62 percent of sales by 2012 (Volpe et al., 2017).

Stores also became much larger. According to FMI (The Food Industry Association), an industry trade organization, average supermarket size grew from 35,100 square feet in 1994 to 48,466 square feet in 2020. While supercenters and warehouse club chains mostly expanded by building large stores in new locations, traditional supermarket chains have also grown across geographical markets through mergers with other supermarket chains. As of 2021, the largest chains were Albertsons, Kroger, and Ahold-Delhaize.[42]

Both factors—mergers and internal growth—accelerated the shift of retail sales to regional and national chains. The share of food stores that were single-store firms, or part of local chains, fell from 55 percent of all food stores in 1977 to 35 percent in 2007 (Foster et al., 2016). In nonmetro counties, the number of food stores that were within single-store firms or local chains (within 1 State) fell 30–40 percent over 2000–15 as sales shifted to regional (chains within 2 to 10 States) and national chains (Stevens et al., 2021). National-chain expansion and nontraditional retailer entry has led to a steady rise in the nationwide concentration of food retail sales (figure 8).

Figure 8
National food retail concentration in the United States, 1990–2019



CR = concentration ratio.

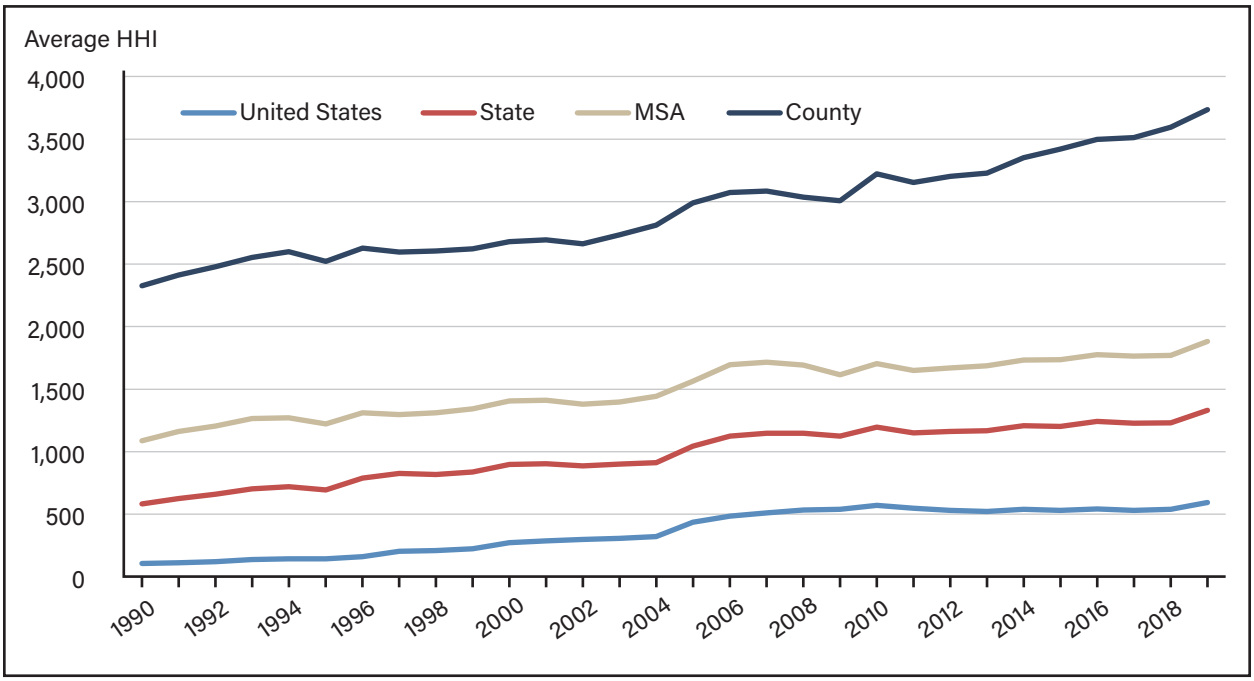
Note: CR20, CR8, and CR4 measure the market share of the largest 20, 8, and 4 firms, respectively.

Source: U.S. Department of Agriculture, Economic Research Service, *Retail Trends* (USDA, ERS, 2022).

[42] In 2022, Kroger proposed to acquire Albertsons. At the time of this writing, this merger was under FTC review.

While the largest four food retail chains held 34 percent of nationwide grocery sales in 2019, concentration within metropolitan areas is considerably higher. There are five or six chains that dominate grocery sales in most metropolitan statistical areas (MSAs), and the average HHI of all food retail sales for core-based statistical area (CBSA) is 1,100 (Ellickson, 2007; Çakır et al., 2020). Concentration measures can be even higher and rising when measured within counties. In 2019, the average HHI ranged from 2,758 in metro counties to 5,584 in rural counties (Zeballos et al., 2023).[43] Moreover, HHI within counties rose substantially between 1990 and 2019, with HHI also increasing at the national level and within State and MSAs (figure 9).

Figure 9
Local food retail concentration, 1990–2019



Note: HHI = Herfindahl-Hirschman Index; MSA = metropolitan statistical area.

Source: USDA, Economic Research Service (Zeballos et al., 2023).

Drivers of Increased Concentration

A set of complex market and technological factors drove the shift to larger stores and chains and higher retail concentration. Large retail stores and chains are better positioned to take advantage of economies of scope (number of products) and scale (size of the firm) (Bronnenberg & Ellickson, 2015). Larger stores can offer a greater variety of fresh and dry food products at lower unit costs of labor and space, especially if they can realize high levels of product turnover.

Technological changes helped facilitate the industry's transformation. Key innovations during the 1980s, such as the introduction of universal product codes (UPCs) and the scanning register, transformed the logistics of supplying stores and expanded the number of products carried in each store (Holmes, 2001). A new industry of data collection and analysis also sprang up to support the processing of sales information. By the mid-

[43] For context, an HHI of 2,758 (the average value for metro counties in 2019) is equivalent to the HHI that would be generated by 3.6 competitors in a market if those firms were of equal size. A value of 5,584 (the 2019 average HHI across rural counties) is equivalent to the HHI that would be generated by 1.8 equal-sized competitors.

1980s, companies like IRI and Nielsen were running extensive consumer panels and integrating purchase and sales information with couponing, price, display, and advertising data for retailers (Ellickson, 2016). Larger chains were better positioned to take advantage of these new services as the large fixed costs associated with them limited their use among smaller chains. In addition, most retail chains integrate distribution into their retail store network and appear to realize economies of scale in physical distribution tasks (warehousing and transportation), along with scale advantages from the application of information technologies to inventory controls and restocking.

Improvements in distribution networks contributed to the expansion of product offerings (Richards & Hamilton, 2006; Holmes, 2011; Ellickson, 2007). The average number of products in stores, as measured by counts of UPCs, rose from 14,000 in 1980 to 51,000 by 2008.[44]

Changing demographics and shifting consumer demand also helped to facilitate the realization of scale and scope economies. Store demand in food retailing depends on the realization of a dense customer base in proximity to the store (Oi, 1992; Lagakos, 2016; Ellickson & Grieco, 2013; Ellickson et al., 2020). Specifically, considerations such as local population density, shopper characteristics such as mobility in the form of automobile use, incomes, and shopper time costs are important elements driving localized demand. In particular, the long suburban population boom fueled the expansion of larger stores with expanded product offerings. Suburban locations feature greater population mobility through car ownership and road networks, allowing residents to shop over a wider expanse. Retail chains reacted by building larger stores with greater product variety, linked to distribution networks of warehouses and trucks. Inside each store, chains began to offer more services to take advantage of the increasing customer demand for convenience and a desire to reduce the cost of searches and extra trips (Bronnenberg, 2018).

As market size and demand grows, the entry of new stores should potentially place downward pressure on local concentration, according to basic economic intuition. However, if retail chains compete on quality (having more products, amenities, cleanliness, and less congestion) as well as on price, and a growing market leads retailers to build bigger stores with better quality, then bigger markets would not necessarily see lower levels of concentration (Sutton, 1991; Ellickson, 2007). Consequently, market retail concentration may not fall in larger markets. Instead, as markets grow, retail chains may invest in more store attributes such as store size, advertising, and product variety that will attract customers.

Vertical Linkages

Food retailers can also affect food supply chains. Larger retail grocery chains often integrate backwards into wholesale distribution by directly entering into contracts with manufacturers (Bonnet & Bouamra-Mechemache, 2016; Richards et al., 2018; Yonezawa et al., 2020). While they do not necessarily integrate further backwards into food processing and agricultural production, they do establish supply chains through contracts with processors and packers of fresh products. Retailers can affect agricultural producers through the standards and specifications they set for their supply chains.

Retail chains frequently sell "private label" products under their own brand. Private label sales accounted for around 20 percent of all retail food sales in 2020, according to surveys administered by a trade association (the Private Label Manufacturers Association). More than 90 percent of consumer-packaged goods categories have private label product options (Cuneo et al., 2015). Moreover, private label growth significantly exceeds

[44] Across all retailing, where similar technological transformations to much larger chains were occurring, entering stores had much higher levels of labor productivity than stores that they replaced. Moreover, the entry of new stores and the exit of older stores accounted for essentially all of the growth in labor productivity in retail stores during the period, as opposed to very little change in labor productivity within continuing stores (Foster et al., 2006).

that of manufacturer brands (18 percent versus 4.5 percent, respectively). While some retail chains operate their own processing plants for private label products, most contract with independent processors, many of which are small or midsize firms that specialize in contract production for retail, institutional, or other buyers. The growth in private labels can be attributed to the growing size of retailers (Cotterill & Putsis, 2000) and allows for larger retailers' more bargaining power against national brands (Gielens et al., 2021).

Retail chains buy large quantities of fresh produce, dairy, and meat products. Retailers typically set precise specifications for packaging, delivery times, and product attributes for these items and, given the volume of their purchases, they usually buy from large processors, packers, and wholesaler intermediaries rather than directly from farms. However, about 23,600 farms sold directly to retail outlets such as restaurants or supermarkets in 2015 (USDA, NASS, 2016). The farms' 2015 sales to retail outlets amounted to $2.4 billion, about 0.6 percent of total farm cash receipts. The farms that participated in such sales were heavily oriented toward specialty crop production (fruits, vegetables, and nursery) rather than field crops or livestock products.

In the last two decades, large grocery and restaurant chains have become much more proactive in specifying production practices in their supply chains, particularly regarding fresh produce, meat, and dairy products. Some specifications aim at procedures for farm production, processing, packaging, and transportation practices to assure food safety (Astill et al., 2019). Chains have also increasingly targeted product attributes, such as chickens raised without antibiotics or beef from cattle raised without added hormones, that reflect aspects of how the animals are raised. Some specifications require new capital investments that may be more onerous for smaller producers and can accelerate consolidation for producers as well. Retailers tend to work through large processors and produce packers to impose their supply chain requirements on farm producers.

Retailers Compete on Price and Other Dimensions

Competition in meatpacking industries occurs primarily through prices, as the wholesale products that are sold (pork and beef cuts, chicken parts, ground products) are quite homogeneous and do not vary much across processors. In biotechnology markets, firms not only compete on seed prices but also on the traits and genetics embodied in the seed, leading to new and improved seeds and crop protection products. Competition in food retailing extends along more dimensions, including prices, store formats, the range of products and services offered as well as their quality attributes, and location and convenience. Different groups of consumers place different valuations on each of these dimensions—that is, consumers are segmented. Consequently, stores often compete on non-price dimensions such as product variety, location, service, and other attributes that matter to consumers.

In particular, retailers may use variety as a strategic tool to soften price competition (Richards & Hamilton, 2006). Product quality can include aspects like availability (avoiding product shortfalls or products out-of-stock); one study showed that competition from Walmart decreased shortfalls among large chains by about a third (Matsa, 2011). In response to new competition from club warehouse stores, retailers increased the frequency of their price changes and changed product assortments to differentiate themselves from the club store (Bauner & Wang, 2019). As retailers compete on these quality dimensions, changes in the degree of competition can also impact the provision of these services. Consumers consider both price and quality of food products in their purchasing decisions, which makes product quality an important consideration for antitrust analysis.

Concentration and Competition

Does increasing retail concentration lead to greater market power for retailers and higher retail prices?. In practice, economists agree that mergers that increase concentration substantially to high levels are likely to be anticompetitive unless there are sufficient offsetting efficiencies gains like economies of scale or other offsetting factors (Miller et al. 2022; Nocke & Whinston, 2022).

Several statistical analyses have focused on entry events (such as the opening of a Walmart or supermarket) or mergers between stores in a market area to examine the impact of changes in concentration on prices. For example, a recent study by Hosken et al. (2018) examined the price impact of 14 grocery mergers that occurred between 2004 and 2009. They found that 5 of the 14 mergers resulted in estimated price increases of more than 2 percent. Five other mergers resulted in price decreases of over 2 percent, and the remaining four mergers generated no significant price changes.

The introduction and expansion of competing formats provided opportunities to study how changes in concentration affect prices, as the new formats often entered markets by building a new store instead of buying an existing one. For example, several studies have examined the impact of Walmart entry into local markets on the prices charged by incumbent stores. Some found that Walmart Supercenter entry reduced local food prices, both by underselling existing food retailers and by inducing these competitors to lower their own prices (Basker & Noel, 2009; Hausman & Leibtag, 2007). However, a more recent study found that Supercenter entry had no effect on the prices charged by incumbent supermarkets (Arcidiacono et al., 2020). That finding aligns with a number of recent studies that concluded that retail grocery chains do not adjust prices in response to changes in the local competitive landscape. For example, in evaluating prices charged for individual products, recent studies such as DellaVigna and Gentzkow (2019), Hitsch et al. (2021), and Dong (2022) show that most U.S. food, drugstore, and mass-merchandise chains charge nearly uniform prices across stores, despite wide cross-store variation in consumer demographics and local concentration. Butters et al. (2022) found that retail chains alter prices in specific stores in response to changes in local costs (such as changes in shipping costs or excise taxes), but do not vary prices in response to local demand changes. Those analyses confirm the widespread use of simple, "rule of thumb" cost-plus pricing strategies, where retailers ignore local demand conditions and focus on costs instead (Eichenbaum et al., 2011; McShane et al., 2016). Taken together, these analyses cast some doubt on the idea that retail price competition occurs at local market levels, as opposed to occurring nationally and in regions.[45]

Mergers and Merger Policy in Food Retailing

Responsibility for antitrust enforcement in food retailing falls to the FTC. In evaluating a merger proposal, the FTC focuses on whether the combination of the two chains will likely lead to anticompetitive effects that, by removing a competitor in the market, may harm consumers. These anticompetitive effects include higher prices, lowers quality, and other effects. Essentially, the FTC must decide whether stores of merging chains compete with one another.

Food retail chains and stores are differentiated from one another through the number and type of products offered, services, quality, amenities, cleanliness, and locations. As competing firms are differentiated geographically, in the set of products they offer, and the particular consumer segments they target, market definition is especially challenging (Hosken et al., 2018).

[45] There is some evidence that national and regional pricing seems to be more of a recent phenomenon. Retail pricing was more localized and tied to local competition previously (Ashenfelter et al., 2006).

Retail mergers frequently attract antitrust scrutiny. For example, the FTC investigated supermarket mergers in 153 antitrust markets over 1998–2007 and ultimately challenged mergers in 134 of those markets (Hanner et al., 2015). Because of the complex nature of competition among stores and the varying geographic scope of local food markets, food retail can be a particularly difficult industry in which to assess the impact of mergers. Although the Horizontal Merger Guidelines published by the FTC and DOJ provide a framework for assessing the degree of overlap, the implementation can be quite involved (see Hosken & Tenn, 2016, for an overview).

In defining geographic markets, the FTC tries to identify those stores in a merger that are likely to have overlapping customers—people who could likely shop at each store. Because shopping decisions are quite local, geographic markets will also be local. Through the early 2000s, the FTC considered MSAs as the relevant geographic market for assessing the impacts of mergers on competition. However, in recent years the FTC has defined geographic markets more narrowly, using mileage radii (up to 10 miles) around the stores owned by chains in a merger. Recent academic studies have also shown that the sales impact to a store due to entry of a Walmart is limited to a 2-mile radius around the store (Ellickson & Grieco, 2013; Arcidiacono et al., 2020).

The large-scale mergers of recent years—creating the modern Kroger, Albertsons, and Ahold-Delhaize chains—largely served to combine firms that did not directly compete with one another because they operated in different parts of the country. When there has been overlap, the FTC has sought divestitures of specific stores in regions where there appeared to be competitive problems. For example, as a condition of approval of the acquisition of Safeway by Albertson's, the FTC required the combined firm to sell off 168 stores in the Western United States. The FTC also required the sale of 330 Family Dollar stores to a private equity firm, Sycamore Partners, before approval of Dollar Tree's proposed $9.2 billion acquisition of Family Dollar in 2017.

Before 2000, FTC merger reviews focused on competition among supermarkets, to the exclusion of supercenters and combination stores. That is, the FTC did not consider that the formats might compete with one another, and that the expansion of one format in an area might place pressure on the prices charged in other formats. In more recent years, the FTC considers supercenters to be competitors with supermarkets, and hence has moved to consider a wider range of store formats as competitors in attracting retail customers. However, format can still matter. In opposing the proposed acquisition of the Wild Oats chain by Whole Foods, the agency successfully argued that the firms competed in a "premium, natural, and organic" market segment, in which other formats had little impact, and that a merger would therefore lead to reduced competition and higher prices charged to consumers in that market.[46]

Localized retail markets do appear to also feature market segmentation across types of formats, as well as price discrimination across seasons and buyer groups, and pricing rivalry among stores (Chevalier, 1995; Richards & Hamilton, 2006). In considering actual cases, the FTC tries to ascertain whether clear market segments exist, through consideration of consumer flows among store formats. Recent findings from industrial organization and antitrust research have led to new tools to focus on consumer substitution patterns between chains and products to evaluate competition in product-differentiated markets (Ellickson et al., 2020; Richards et al., 2018; Thomassen et al., 2017; Nevo, 2011; Berry et al., 1995; Shapiro, 1996). These new tools and methods use consumer surveys, store data, and scanner data to determine the degree of consumer substitution between chains to establish the degree of competition between potential competitors with regards to the merging parties.

[46] Although the case did not involve food products, retail format was also an important consideration as part of the FTC 's successful challenge of the proposed merger between Staples and Office Depot (Hosken and Tenn, 2016).

Some of these tools such as diversion ratios—the fraction of customers leaving Chain A that switches to Chain B if the price of Chain A increases—were incorporated in the 2010 merger guidelines.[47] Using these concepts, new studies show evidence that consumers prefer to travel relatively short distances for groceries and that substantial cross-format competition exists between supercenters, clubs, and traditional grocers (Ellickson et al., 2020).

Buyer Power and the Use of "Slotting Fees"

While merger enforcement has primarily focused on the likely effects on product markets and prices charged to consumers, there is also interest in retailers' market power as buyers. Some economic theories suggest the possibility of monopsony power exercised through a reduction in input purchases will also reduce output, thereby lowering input prices and raising output prices.

In this context, retail mergers may change local market concentration; however, input markets, such as for fresh produce, meat products, dry groceries, and many dairy products, are typically national. While national retail concentration is increasing, the current level (CR4 of 34) is not one that indicates competitive concerns, even before consideration of the additional buyer competition provided by foodservice and export buyers.[48]

There is interest among policymakers in certain types of retailer purchase practices—in particular, slotting fees—and their potential use in facilitating market power. Slotting fees, also commonly known as slotting contracts or slotting allowances, are fixed lump sum payments made by manufacturers to retailers. Slotting fees often come in the form of one-time payments that a supplier and/or manufacturer makes to a retailer as a condition for the initial placement of the product on the retailer's store shelves or for initial access to the retailer's warehouse space (FTC, 2003). Since the 1980s, the cost and frequency of slotting fees have rapidly grown, which has also coincided with the increasing concentration of retail stores since 1990.

Supermarket slotting arrangements have been the focus of congressional hearings (U.S. House, 1999; U.S. Senate, 1999, 2000). A key issue surrounding slotting fees is their association with retail market power as a mechanism to appropriate supplier profits. Some industry insiders have observed that "there is a consensus among industry observers that the perceived shift in the balance of power from manufacturers to retailers in recent years has contributed to an increase in the incidence and the magnitude of upfront payments. Small manufacturers, who may have little bargaining power, may be particularly vulnerable (Marx & Shaffer 2007)." Furthermore, one panelist from FTC (2001a) stated that "manufacturers and retailers agree that slotting allowances are associated with the exercise of retail market power," and another stated, "When it comes to small manufacturers, the retailer probably has all of the power."

However, some see a different competitive concern: Slotting arrangements can be used by manufacturers to disadvantage rivals by making it more costly for new, potentially competing firms to enter the market. With higher costs of entry, incumbent manufacturers can consequently increase prices (FTC, 2001b).

There are few empirical analyses of slotting fees because of limited data on the practice, and as a result most academic studies have used theoretical modeling of retailer and manufacturer optimizing strategies to simulate both the outcome and the degree of harm or benefit to retailers, manufacturers, and consumers. Some studies show that slotting allowances can have anti-competitive effects in the presence of market power either upstream (by manufacturers) or downstream (by retailers). With upstream market concentration of manu-

[47] "The agencies rely much more on the value of diverted sales than on the level of the HHI for diagnosing unilateral price effects in markets with differentiated products," per 2010 FTC and DOJ Horizontal Merger Guidelines.

[48] Other studies note that it may not be in the long-term interest of retailers to leverage market power if it drives out and reduces of the number of suppliers (Sexton & Xia, 2018; Sexton, 2013; and Swinnen & Vandeplas, 2010).

facturers, slotting contracts could be used to raise the costs of entry for new manufacturing entrants (Shaffer, 2005). In theory, slotting fees could also enable one retailer and a monopoly manufacturer of a specific product to prevent a rival retailer from access to stocking that product (Marx & Shaffer, 2007). These fees could also enable national brand manufacturers to control the retail prices of other competitively supplied products (Innes & Hamilton, 2006, 2009).

The required conditions for these anticompetitive effects to occur are mostly nonexistent in food retail as slotting contracts are frequently used with manufacturers that hold relatively small market shares (Klein & Wright, 2007). Moreover, many slotting contracts merely require a retailer to stock or dedicate a particular amount of display space or shelf location to the manufacturer's product, without any exclusivity requirement that retailers can only sell their product or vice versa. In food retail, competition between incumbents and entrants for retail distribution generally occurs on a level playing field in the sense that all manufacturers can openly compete for shelf space and it is the manufacturer willing to pay the most for a particular space that obtains it. Slotting fees are payments that must be borne by all manufacturers and are not necessarily anti-competitive. Competition for shelf space that leads to slotting may raise the cost of obtaining retail distribution, but it does so for all manufacturers (Klein & Wright, 2007).

Conclusions

Concentration in the food retail industry has steadily increased during the past 30 years as chains have become more national and stores have grown larger in terms of physical size and number of products offered. New innovations and changing consumer demand have created opportunities for retailers to make use of the resulting scale efficiencies and scope economies of these larger stores and chains. The transformation of food retailing has led to a range of competing store formats and chain strategies, competing along price, convenience, quality, and variety dimensions. Consumers also tend to fall into multiple segments of shoppers, who vary in the value they place on price, convenience, variety, quality, and other features. Although food retailing concentration has increased in the last 30 years, more in-depth research could examine the competitive impact of increasing concentration (Sexton & Xia, 2018; Dong et al., 2023).

For antitrust policy and merger review, the differentiated nature of food retail can complicate attempts to define both the relevant product and geographic markets for market concentration calculations compared with markets with more similar products such as seeds or meatpacking. More recent merger reviews in food retail have focused on localized markets and have required in-depth analysis to decide on the inclusion of certain store formats as relevant substitutes to estimate market concentration and assess competitive impact.

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