Case Study

Price-Fixing in the U.S. Broiler Chicken and Pork Industries

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Abstract
The motivations for this case study are recent developments in the U.S. broiler chicken and pork industries involving implementation of agricultural supply control practices by the largest broiler and pork processors in the United States. Buyers of broilers and pork filed antitrust lawsuits alleging that by implementing these supply control practices broiler and pork processors engaged in unlawful price-fixing conspiracies. The case study introduces economic, business, and legal issues related to implementation of supply control practices in the U.S. broiler chicken and pork industries. The case study presents economic models that help explain the conduct and performance of these industries in the analyzed setting, and it includes a basic market and price analysis. The intended audiences are undergraduate and graduate students, as well as extension and outreach communities. The teaching note includes multiple-choice questions and suggested answers to analytical, discussion, and multiple-choice questions. The teaching note also discusses teaching objectives, teaching strategies, and student background knowledge.

1 Introduction

The U.S. broiler chicken[1] and pork industries are concentrated industries, meaning a relatively small number of large broiler and pork processors produce and market most of the broiler chickens and pork products in the country. In 2020, the combined market share of the ten largest broiler processors was approximately 80 percent, and the combined market share of the two largest companies, Tyson Foods and Pilgrim's Pride (JBS USA), was almost 37 percent (Table 1). The same year, the combined market share of the ten largest pork processors was approximately 86 percent, and the combined market share of the two largest companies, Smithfield and JBS USA, was 43.6 percent (Table 1).

The U.S. broiler and pork industries are vertically integrated industries (MacDonald 2008; McBride and Key 2013; MacDonald 2014; National Chicken Council 2022). The broiler and pork processors control production processes at consecutive stages of the broiler and pork supply chains by using complex production contracts with broiler growers and hog farmers and/or by operating their own farms. For example, under production contracts, broiler and pork processors have control over the breeding stage, feed production stage, production (farm) stage, and processing stage of the broiler and pork supply chains. Broiler and pork processors own broilers and hogs at the production (farm) stage and maintain the product ownership throughout the supply chain. Consequently, broiler and pork processors make decisions affecting quantities of broilers and hogs produced at the production (farm) stage. Under production contracts, broiler growers and hog farmers provide services of growing broilers and raising hogs for broiler and pork processors in exchange for a fee.

Beginning in 2008, the largest broiler and pork processors implemented a series of agricultural supply control practices ("production cuts"), which affected quantities of broilers and pork produced and marketed in the country. The broiler and pork processors implemented production cuts to mitigate

[1] Broiler chickens are chickens raised for meat production. They will be referred to as "broilers" in this case study.

Table 1. The Ten Largest Companies in the U.S. Broiler Chicken and Pork Industries and Their Market Shares, 2020

	Broiler Chicken Industry				Pork Industry		
	Company	Production	Market share		Company	Plant slaughter capacity	Market share
		Million pounds per week	Percent			Heads per day	Percent
1	Tyson Foods	200.70	20.38		Smithfield	130,300	25.4
2	Pilgrim's Pride	161.66	16.4 (36.8)		JBS	93,000	18.2 (43.6)
3	Sanderson Farms	94.31	9.6 (46.4)		Tyson Foods	81,800	16.0 (59.5)
4	Mountaire Farms	62.13	6.3 (52.7)		Clemens Food	23,700	4.6 (64.2)
5	Perdue Foods	61.26	6.2 (58.9)		Seaboard Farms, OK	22,500	4.4 (68.6)
6	Koch Foods	60.74	6.2 (65.1)		Triumph Foods	21,300	4.2 (72.7)
7	Wayne Farms	48.80	5.0 (70.0)		Seaboard Farms, IA	20,400	4.0 (76.7)
8	Peco Foods	36.04	3.7 (73.7)		Hormel	19,000	3.7 (80.4)
9	George's	30.60	3.1 (76.8)		Indiana Packing Co.	16,700	3.3 (83.7)
10	House of Raeford Farms	28.90	2.9 (79.7)		WholeStone Farms	11,500	2.2 (85.9)
	Industry Total	984.74	100.0		Industry Total	512,370	100.0

Note: The broiler chicken production is the ready-to-cook weight of broiler chickens produced; the data are from WATT PoultryUSA (2021) and O'Keefe (2021). The pork plant slaughter capacity is from Meyer (2020). Market shares are calculated by the author. The cumulative market shares are in parentheses.

agricultural supply volatility and increases in feed prices, which contributed to an oversupply (overproduction) problem adversely affecting their profitability. There was a consistent increase in the quantities of broilers and pork produced, which the market could not absorb at prices profitable for broiler and pork processors.

Beginning in 2016, direct and indirect buyers of broilers and pork products started filing class action antitrust lawsuits against the largest broiler and pork processors.[2] The buyers alleged that by implementing production cuts and publicly communicating their intentions to implement these production cuts, the broiler and pork processors engaged in conspiracies (illegal agreements) with the purpose of fixing, increasing, and stabilizing prices of broilers and pork products paid by various participants in the broiler and pork supply chains (wholesalers, retailers, and final consumers), and consequently violated Section 1 of the Sherman Act (Popken 2017; Dewey 2018; Isidore 2018; Marotti 2018; Meyer 2018; National Hog Farmer 2018; Welshans 2018).[3] Beginning in 2017, some of the broiler and pork processors (defendants) started settling the lawsuits (Broiler Chicken Antitrust Litigation webpage 2022; Devenyns 2021; Pork Antitrust Litigation webpage 2022; Stempel 2021). As of the beginning of 2022, settlements with private parties in the broiler and pork industries totaled approximately $363 million and $122 million, respectively.

[2] Direct buyers (purchasers) are the ones who purchased broiler chickens and pork products directly from defendants. The examples of direct buyers are food retailers, wholesalers, restaurants, and institutional buyers. Indirect buyers (purchasers) are the ones who purchased these products indirectly from defendants, in particular from companies which sold these products but were not the defendants. The examples of indirect buyers are final consumers purchasing products from food retailers.

[3] Students are encouraged to read these magazine articles prior to studying the case study.

This case study introduces economic, business, and legal issues related to implementation of agricultural supply control practices in the U.S. broiler and pork supply chains. The case study presents economic models, which may explain conduct and performance of these industries in the analyzed situation, and a basic empirical market and price analysis utilizing publicly available data from the U.S. Department of Agriculture (USDA). The case study also highlights relevant antitrust issues.

This case study is suitable for a variety of undergraduate and graduate courses taught in agricultural economics and agribusiness programs, including microeconomics, agricultural economics, managerial economics, agricultural (or agribusiness) marketing, agricultural markets and prices (or agricultural prices), agribusiness management, supply chain management, and applied industrial organization. The case study is also suitable for extension and outreach communities. Table 2 summarizes student learning objectives.

Table 2. Student Learning Objectives (SLOs)

	Student Learning Objective
SLO #1	Students should be able to discuss structures of the U.S. broiler and pork industries.
SLO #2	Students should be able to explain production systems in the broiler and pork industries and discuss agricultural supply control practices (production cuts) implemented by the largest broiler and pork processors.
SLO #3	Using a graphical analysis, students should be able to explain two economic models, which may describe conduct and performance of the broiler and pork industries (changes in output quantity and output price; broilers and pork are "output") in the two situations. In the first situation, the industries are assumed to behave as classic oligopolies forming output price-fixing cartels. In the second situation, the industries are assumed to behave as perfectly competitive industries adjusting output quantity produced in response to increasing marginal cost (feed prices).
SLO #4	Students should be able to perform a basic empirical market and price analysis to evaluate changes in the market and price behavior in the broiler and pork industries between the period of agricultural supply control practices and a prior period.
SLO #5	Students should be able to conduct a price analysis and price forecast in the broiler and pork industries by using price flexibilities.
SLO #6	Students should be able to discuss legal (antitrust) issues involved and explain the role of the Sherman Act in regulating conduct of broiler and pork processors in the analyzed industry setting.

2 U.S. Broiler Chicken and Pork Industries: Structures

This section discusses structures of the broiler chicken and pork industries prior to the period of agricultural supply control practices and highlights changes in market concentration in the last 15 years.

The U.S. broiler and pork industries are concentrated industries. There is a relatively small number of large firms controlling most of the production and marketing in these industries. In 2007, prior to the implementation of agricultural supply control practices, the five-firm concentration ratio

(CR5)[4] in the broiler industry was 60.9 percent, and the ten-firm concentration ratio (CR10) was 75.8 percent (Weaver 2014). As of 2007, Pilgrim's Pride and Tyson Foods were the two largest firms in the broiler industry, with respective market shares of 31.3 percent and 25.9 percent; Perdue Farms was the third largest firm with a market share of 10.0 percent (Congressional Research Service 2009). In 2007, the five-firm concentration ratio (CR5) in the pork industry was 74.3 percent (Congressional Research Service 2009). As of 2007, Smithfield Foods and Tyson Foods were the two largest firms in the pork industry, with respective market shares of 28.4 percent and 17.6 percent; JBS USA was the third largest firm with a market share of 11.1 percent (Congressional Research Service 2009).

Several economically significant acquisitions took place in both industries in the period of 2007–2013 (Congressional Research Service 2009; Johnson 2009). JBS S.A. purchased Swift and Pilgrim's Pride in 2007 and 2009, respectively. After acquiring Pilgrim's Pride, JBS became the second largest broiler processor in the United States. JBS and Tyson Foods are companies operating in both the broiler and pork industries. Smithfield Foods was purchased by a Chinese-based company in 2013 (Daily Livestock Report 2013).

As indicated by changes in the four-firm concentration ratio (CR4), market concentration decreased in the broiler industry over the last 15 years. Given that since 2006 smaller companies grew faster than the largest companies in the broiler industry, its CR4 decreased from 57.8 percent in 2006 to 52 percent in 2020 (O'Keefe 2021). The combined market share of the two largest broiler processors, CR2, decreased from approximately 45 percent in 2006 to 35 percent in 2020 (O'Keefe 2021). As of 2020, the four largest companies in the broiler industry were Tyson Foods, Pilgrim's Pride (JBS USA), Sanderson Farms, and Mountaire Farms, followed by Perdue Foods and Koch Foods (Table 1).

Market concentration in the pork industry decreased in recent years. Because several new pork processing plants owned by hog producers were opened in Iowa, Minnesota, and Michigan in the last few years, CR4 in the pork industry decreased from approximately 70 percent in 2016 to 64 percent in 2020 (Meyer and Goodwin 2021). As of 2020, the four largest companies in the pork industry were Smithfield, JBS, Tyson Foods, and Clements Food Group, followed by Seaboard Farms and Triumph Foods (Table 1).

Broiler chickens and pork products are homogeneous products, which means that broiler chickens and pork produced by different processors are essentially the same products, with a small degree of product differentiation present. Buyers, who purchase these products directly from processors (retailers, wholesalers, restaurants, and institutional buyers), are relatively indifferent about which processor to buy these products from. Consumers purchasing these products at the retail level face some degree of product differentiation depending on whether they purchase raw meat (whole chickens, chicken parts, pork chops, pork ribs, etc.) or more processed products (chicken nuggets, sausages, bacon, etc.). Some of these products are completely cooked and can be consumed without any additional preparation at home, and some products require further preparation at home. At the retail level, broiler chickens and pork products are marketed under the brands of processors and food retailers.

Given product homogeneity, broiler and pork processors compete on price. The demand for broiler chickens and pork is inelastic. Broiler chickens and pork are products, which are imperfect substitutes to each other. Other products, which are imperfect substitutes to broiler chickens and pork, include other types of red meat (beef and lamb), other types of poultry (turkey), and fish. The broiler and pork industries have high barriers to entry. This means that a firm, which considers entering the industry, must incur substantial costs to build a processing plant or to purchase an existing plant.

[4] The *N*-firm concentration ratio is a commonly used measure of market concentration, which represents a combined market share of the *N* largest firms in the industry (Besanko et al. 2006). CR4 ($N = 4$) is the most frequently used measure. The firms' market shares are typically calculated using the firms' revenue (sales). A high level of market concentration can facilitate anticompetitive conduct of firms operating in concentrated industries. It is considered that if CR4 exceeds 75 percent, an industry is conducive to collusion, and if CR4 is smaller than 40 percent, an industry is not likely to present competition concerns (Hovenkamp 2005).

3 Agricultural Supply and Price Cycle, Production Systems, and Production Cuts

As in many agricultural industries, the broiler and pork industries are affected by a high level of agricultural supply and price volatility. This volatility is mostly due to the biological nature of agricultural production and other factors that agricultural producers (processors in this case study) cannot control (weather conditions affecting animal growth, a high volatility of feed and energy prices, animal diseases, etc.).

Agricultural producers tend to base their future production decisions on current output prices and profit, rather than on future prices (Kohls and Uhl 2002). Generally described, a natural agricultural production and price cycle is such that agricultural producers increase output quantity produced in response to high output prices, which will cause output prices to decrease in the future. Agricultural producers decrease output quantity produced in response to low output prices, which will cause output prices to increase in the future. This natural agricultural supply and price cycle leads to market situations (years) where there is overproduction (oversupply) of agricultural products, and output prices are below production costs, resulting in financial losses for producers and their industries (Kohls and Uhl 2002; Bolotova 2019).

This is especially true in the broiler chicken and hog/pork industries, where there is a time lag between the moment producers observe current output prices and the moment they adjust (increase or decrease) output quantity produced in response to these prices (Kohls and Uhl 2002; Norwood and Lusk 2008). In addition, there is a time lag between the moment production decisions are made and the moment the output is produced and marketed. Due to differences in biological cycles, agricultural supply and price cycles in the broiler chicken industry are much shorter than in the hog industry. As little as 8 weeks may take place between the moment a chicken is hatched and the moment it is sold to a wholesale or retail customer (Pruitt and Lavergne 2013). It takes approximately 25 to 28 weeks to raise a hog from the moment it is born to the moment it is sold to a processor (Pork Checkoff 2022a).

The following subsections briefly discuss production systems for broiler chickens and hogs/pork, decision makers whose decisions affect quantities of these products produced, and agricultural supply control practices implemented by the largest broiler chicken and pork processors.

3.1 Broiler Chickens

The production process for broiler chickens includes six vertically aligned stages (MacDonald 2008; MacDonald 2014; Weaver 2014; National Chicken Council 2022).[5]

1. Primary breeding stage: primary breeding companies produce breeder chicks with desirable genetics characteristics, which are delivered to breeder farms.
2. Breeder stage: on breeder farms, breeder chicks are raised to produce fertilized eggs, which are delivered to hatcheries.
3. Hatching stage: in hatcheries, fertilized eggs are placed in incubators (the incubation period is 3 weeks); young chicks are hatched, vaccinated, and delivered to grow-out farms.
4. Grow-out (farm) stage: on farms owned and operated by broiler growers, young chicks are raised to a desirable market age and weight (6 to 7 weeks).
5. Feed manufacturing stage: feed mills mix feed rations, which are used to feed breeder chicks and broiler chicks. The feed mixes include corn, soybean meal, and added vitamins and minerals.
6. Processing stage: in processing plants, chickens are slaughtered and processed in various chicken cuts and chicken products to be sold to wholesalers, retailers, restaurants, institutional buyers,

[5] A figure depicting these production stages can be downloaded on the webpage of the National Chicken Council, https://www.nationalchickencouncil.org/industry-issues/vertical-integration/.

and export customers. Chicken by-products are utilized by rendering plants.

The U.S. broiler chicken industry has a high degree of vertical integration. This means that broiler processors (integrators) maintain the ownership of broiler chickens at all stages of the broiler supply chain. Approximately 90 percent of broiler chickens are raised under production contracts between broiler processors and broiler growers, about 9 percent of broiler chickens are raised on the farms owned by processors, and the remaining 1 percent is raised by independent chicken growers (National Chicken Council 2022).

Broiler processors own feed mills, hatcheries, and processing plants (Weaver 2014; National Chicken Council 2022). Broiler processors use complex production contracts with broiler growers, according to which broiler growers raise broiler chickens for broiler processors in exchange for a fee. Broiler growers do not own broiler chickens they raise for broiler processors. Production contracts specify responsibilities of broiler processors and broiler growers in great detail (Pilgrim's Pride Broiler Production Agreement 2005; MacDonald 2008; MacDonald 2014). Typically, under production contracts, broiler processors are responsible for providing young chicks, feed, veterinary supplies and services, and transportation of chickens to and from the farms, and they also determine production management practices. Broiler growers are responsible for providing chicken housing facilities, land, labor, utilities, operating expenses, and following production management practices determined by the processor. Because of the widespread use of production contracts, broiler processors are "agricultural producers" who make decisions affecting the quantity of broiler chickens produced at the farm (grow-out) stage of the broiler supply chain.

Feed (corn and soybean meal) is the major input used in broiler production. The feed costs represent approximately 65 to 75 percent of broiler production costs (Weaver 2014). A dramatic increase in feed prices, coupled with the effect of broiler supply and price developments, adversely affected the profitability of broiler processors in the period between 2006 and 2012 (Weaver 2014; *In Re Broiler Chicken Antitrust Litigation* 2019). The prices of corn and soybean meal, the two major feed types used in broiler production, started increasing in 2006 and reached a dramatically high level in the period between 2008 and 2012 (Becker 2008; Schnepf 2008; Weaver 2014), partially contributing to the oversupply of broiler chickens. There was a consistent increase in the quantity of broilers produced, which the market could not absorb at prices profitable for broiler processors. At the same time, due to the 2008–2009 economic recession, broiler demand was declining (Weaver 2014).

The bankruptcy of Pilgrim's Pride in 2009 was evidence of profitability issues in the broiler industry. The company could not maintain a viable profitability level due to increasing feed prices and low chicken prices and filed for bankruptcy. The company was purchased by JBS SA (Chasan and Burgdorfer 2009; Spector, Etter, and Stewart 2009). Changes in the feed cost and wholesale broiler price indices presented in Figure 1 indicate that during the period of 2008 to 2014, the feed cost index level is much higher than the wholesale price index level, which reflects profitability issues in the broiler industry during this period.

A group of the largest broiler processors implemented a series of production cuts at various stages of the broiler supply chain beginning in 2008 to decrease quantities of broilers produced in a period of increasing feed prices and declining demand to maintain a viable profitability level and to avoid financial losses (Weaver 2014; *In Re Broiler Chicken Antitrust Litigation* 2019). The combined market share of the largest broiler processors, who implemented production cuts, was approximately 90 percent (*In Re Broiler Chicken Antitrust Litigation* 2019).

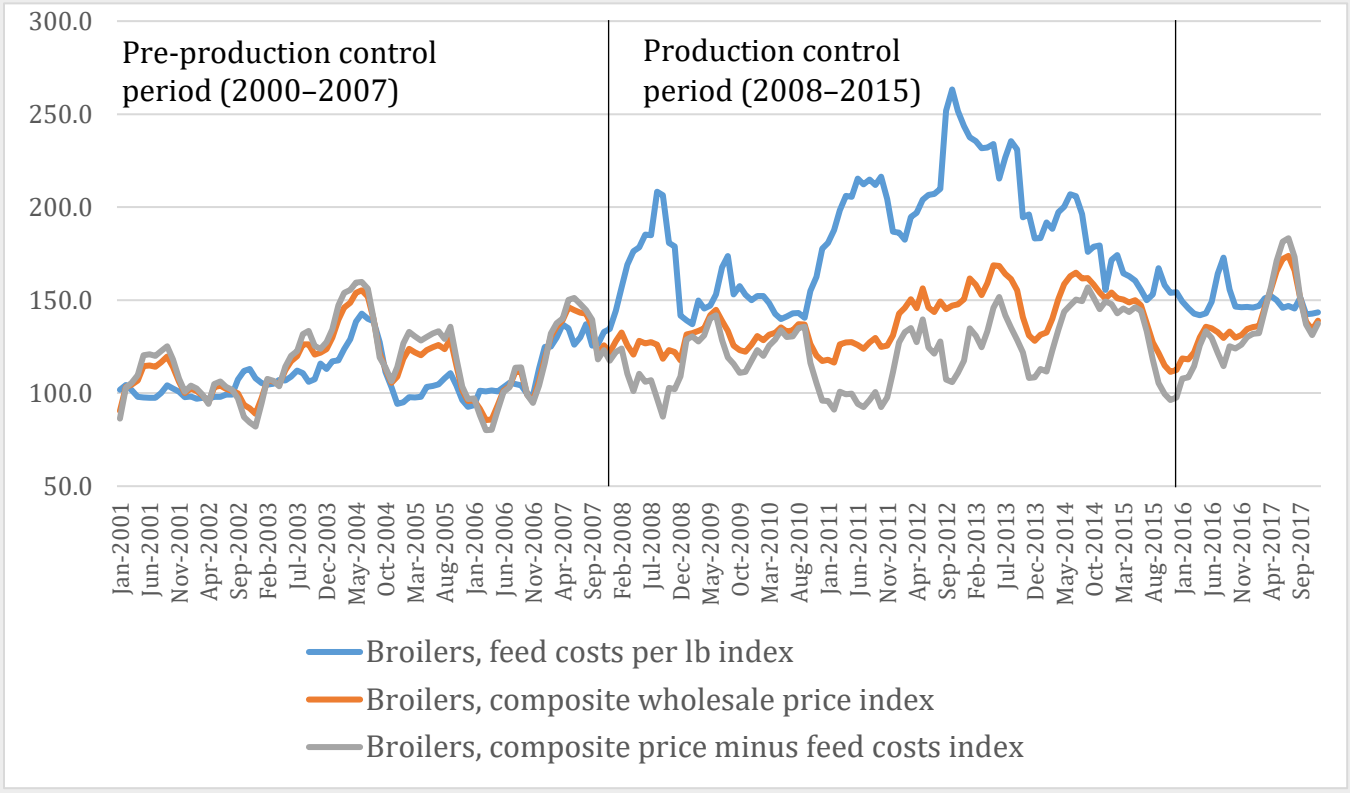

Figure 1. U.S. Broiler Chicken Industry: Monthly Feed Costs Index, Wholesale Price Index, and Wholesale Price Minus Feed Costs Index, 2001—2017

Data source: USDA, Economic Research Service (2022b).

- At the breeder stage, broiler processors decreased the size of breeder flocks (killed broiler breeders prematurely before their optimum age and purchased a smaller quantity of breeder pullets from genetics companies).
- At the breeder stage, broiler processors decreased the size of egg sets (the number of eggs placed in incubators) by breaking eggs and selling them to rendering plants.
- At the hatching stage, broiler processors destroyed newly hatched chicks before delivering them to broiler growers.
- At the grow-out (farm) stage, broiler processors decreased the number of young chicks delivered to contract growers, increased the time period between picking up mature chickens from broiler growers and delivering young chicks to broiler growers.
- At the processing stage, broiler processors decreased the size (weight) of broiler chickens at slaughter by slaughtering them before they reached mature age.
- At the processing stage, broiler processors slowed down and/or closed (temporary or permanently) processing plants.
- Broiler processors increased export of chicks and broiler chickens, which decreased their quantities available for the domestic market.

The largest broiler processors periodically made public statements regarding their intent to implement production cuts. The following excerpts are three examples of these statements.

(1) "In response, Pilgrim's ***issued a call to action for its competitors to reduce their production of Broilers to allow prices to recover***. On a January 29, 2008, earnings call, Pilgrim's CFO … said ***the industry was oversupplying Broilers and it was hurting market prices.*** [CFO] explained ***that his company had done its part in 2007 by reducing production 5 percent, so 'the rest [] of the market is going to have to pick-up a fair share in order for the production to come out of the system'***" (*In Re Broiler Chicken Antitrust Litigation* 2019, paragraph 191).

(2) "Only a month and a half after installing its new CEO, Pilgrim's ***again led the charge to cut overall industry supplies***, but this time it backed up its rhetoric with production cuts. On March 12, 2008, Pilgrim's announced a massive closure of its Broiler processing plants. Just five days after taking over the position of Pilgrim's CEO, …, ***publicly announced the closure of seven Broiler facilities in order to reduce industry oversupply***, stating ***'we believe [these] actions . . . are absolutely necessary to help bring supply and demand into better balance . . . . That portion of the demand for our products that exists solely at pricing levels below the cost of production is no longer a demand that this industry can continue to supply'***" (*In Re Broiler Chicken Antitrust Litigation* 2019, paragraph 194).

(3) "On April 3, 2008, Fieldale Farms ***announced a 5 percent production cut***. In connection with the cut, Executive Vice President … commented that ***Fieldale has had trouble passing on cost increases to both foodservice and retail customers***. ***'Every time we try [to increase prices], one of our competitors comes in with a price lower than our previous price,'*** ..... Fieldale, which has been absorbing feed-cost increases, hopes its move will help ease continuing price pressure. ***'We can't sell [some of] the chickens at a price higher than the cost,'*** .... ***'We're hoping this cut puts supply and demand back into better balance'***" (*In Re Broiler Chicken Antitrust Litigation* 2019, paragraph 195).

Table 3 presents data on yearly broiler production, wholesale prices, percentage changes in the production and price, and price flexibilities for the period of 2000–2015 (Figure 2 depicts production and prices).[6] In the pre-production control period (2000–2007), all percentage changes in broiler production are positive, meaning that in this period broiler production was increasing.[7] This consistent increase in the quantity of broilers produced each year might have contributed to the oversupply (overproduction) of broilers and low wholesale broiler prices not being profitable for broiler processors.

In the production control period (2008–2015), percentage changes in broiler production are both positive and negative. The decreases in broiler production are observed only in 2 years: -3.78 percent in 2009 and -0.44 percent in 2012. These decreases in yearly production likely reflect the effects of production cuts, given that broiler processors implementing production cuts controlled approximately 90 percent of the wholesale broiler market. The increases in broiler production are in the range of 0.79 percent in 2011 to 3.94 percent in 2010. The percentage increases in broiler production might also reflect the effects of production cuts, in which case the growth of broiler production was slowed down.

[6] Nominal wholesale prices of broiler chickens (these are actual market prices that are not adjusted for inflation) are used in the empirical analysis presented in the case study. A discussion of the rationale for using nominal wholesale prices as opposed to real wholesale prices is discussed in Appendix I. The latter also presents a descriptive statistical analysis of real wholesale prices.

[7] The total broiler chicken production each year is affected by the number of broiler chickens slaughtered and the weight of each broiler chicken.

Table 3. The U.S. Broiler Chicken Production, Wholesale Prices, and Price Flexibilities, 2000—2015

Year	Broiler Production (Q)	Wholesale Broiler Price (P)	Change in Broiler Production	Change in Wholesale Broiler Price	Broiler Price Flexibility
	Million pounds	Cents per pound	Percent	Percent	$\frac{\%\ change\ in\ P}{\%\ change\ in\ Q}$
Pre-Production Control Period (Pre-PC Period): 2000–2007					
2000	30,209.0	53.54			
2001	30,938.0	62.04	2.41	15.87	6.6
2002	31,895.0	55.95	3.09	-9.81	**-3.2**
2003	32,398.6	65.65	1.58	17.34	11.0
2004	33,699.0	76.70	4.01	16.82	4.2
2005	34,986.0	67.69	3.82	-11.74	**-3.1**
2006	35,119.7	56.28	0.38	-16.86	**-44.1**
2007	35,772.2	76.22	1.86	35.44	19.1
Production Control Period (PC Period): 2008–2015					
2008	36,511.5	71.16	2.07	-6.64	**-3.2**
2009	35,130.8	75.50	-3.78	6.09	**-1.6**
2010	36,515.1	74.32	3.94	-1.56	**-0.4**
2011	36,804.4	71.46	0.79	-3.85	**-4.9**
2012	36,643.0	84.53	-0.44	18.29	**-41.7**
2013	37,425.3	88.30	2.13	4.47	2.1
2014	38,152.5	86.89	1.94	-1.60	**-0.8**
2015	39,619.8	77.33	3.85	-11.01	**-2.9**

Note: Data source for yearly broiler production and monthly wholesale prices is USDA, Economic Research Service (2022a, 2022b). Yearly prices are calculated by the author using monthly prices reported in USDA, Economic Research Service (2022b).

The broiler price flexibilities vary in magnitude over time.[8] The majority of price flexibilities with the expected negative sign are in the range of -1 to -5 in both periods. For example, a price flexibility calculated for 2009 is -1.6, indicating that a 1 percent decrease in broiler production in the period of 2008–2009 caused a 1.6-percent increase in the wholesale price of broilers in 2009.

[8] Price flexibilities are elasticities associated with price-dependent (inverse) demand functions (Moore 1919; Houck 1965; Hudson 2007). Price flexibility indicates a percentage increase (decrease) in product price, which follows a 1-percent decrease (increase) in product quantity demanded. Theoretically, price flexibilities are expected to be negative. The positive values for price flexibilities reported for selected years are not as expected. These positive values may reflect the effects of changes in a variety of factors affecting prices and quantities of broiler chickens: prices and quantities of products-substitutes (beef and pork), consumer income, production costs (for example, feed prices and fees paid to contract broiler growers), and new production technologies leading to increasing productivity (increasing chicken weight). Appendix II discusses price flexibilities in greater detail.

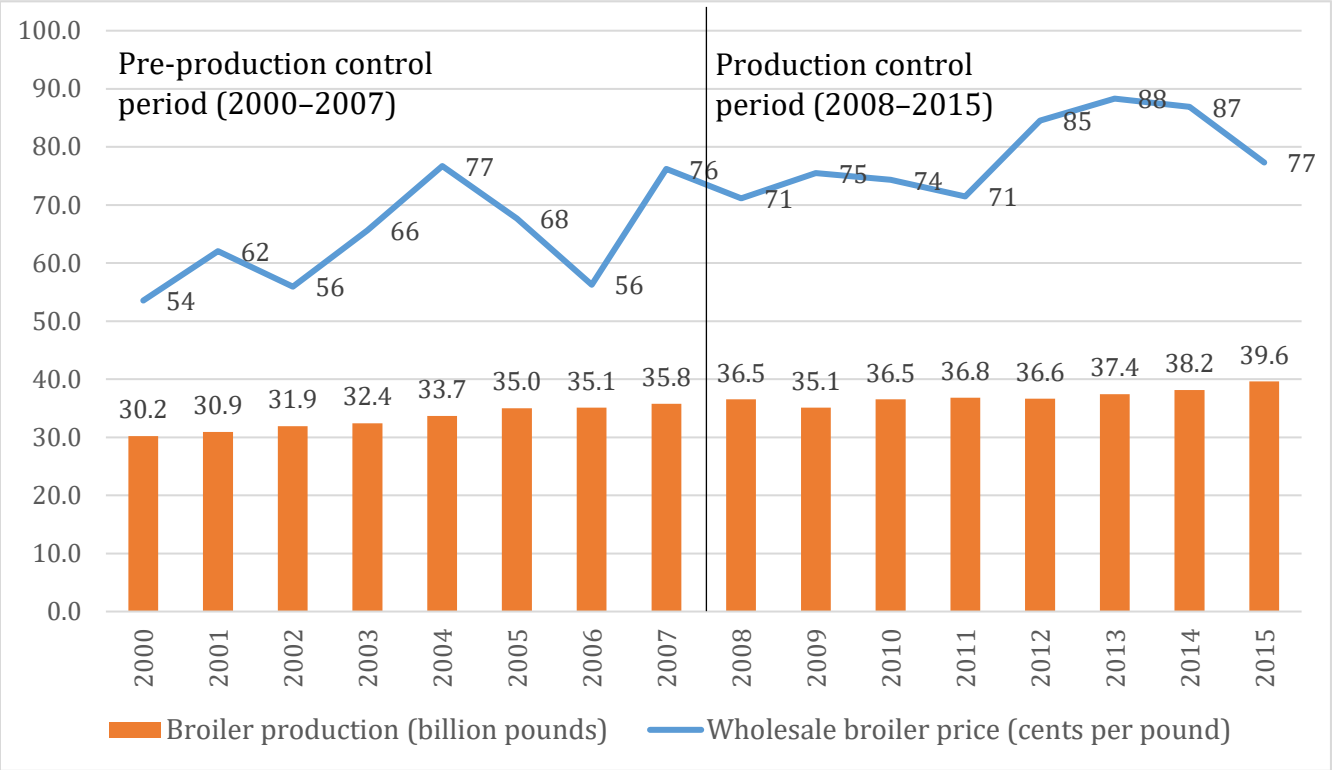

Figure 2. The U.S. Broiler Chicken Production and Wholesale Prices (Yearly Data), 2000–2015

Data source for yearly broiler production and monthly wholesale prices is USDA, Economic Research Service (2022a, 2022b).
Note: Yearly prices are calculated by the author using monthly prices reported in USDA, Economic Research Service (2022b).

The absolute value of the majority of calculated broiler price flexibilities is greater than one, reflecting inelastic demand for broilers. Because a percentage change in broiler price is greater than a percentage change in broiler quantity, broiler processors would benefit from decreasing the broiler quantity produced even by a small percent, which would cause the wholesale broiler price to increase by a greater percent.

3.2 Hogs and Pork

The production process of hogs slaughtered to manufacture pork products includes four stages (McBride and Key 2013; Giamalva 2014; Pork Checkoff 2022a).

1. Breeding and gestation stage: female hogs are bred and cared for during gestation period (3 months, 3 weeks, and 3 days).
2. Farrowing stage: baby pigs are born and cared until weaning, when they are 3 weeks of age and weigh 13 to 15 pounds (3 weeks).
3. Nursery stage: piglets are cared for after weaning until they reach weight of about 50 to 60 pounds (6 to 8 weeks).
4. Finishing stage: hogs are fed until they reach a slaughter weight of approximately 280 pounds (16 to 17 weeks).

Hog producers (farmers) are categorized based on the number of hog production stages taking place at the same operation: farrow-to-finish (all four stages), farrow-to-feeder (stages #1–3), feeder-to-finish (stage #4), wean-to-feeder (stage #3), and farrow-to-wean (stages #1–2; McBride and Key 2013).

While in the past, most hog producers were farrow-to-finish operations, the recent trend is for hog producers to specialize on a single stage (McBride and Key 2013).

As for the decision-making process affecting the quantity of hogs produced, both hog producers and pork processors make decisions affecting this quantity. Traditionally, hog producers as hog owners, who sell their hogs in the spot market or use marketing contracts,[9] have been making decisions affecting hog quantity produced. In recent decades, the use of production contracts between hog producers and pork processors has increased (McBride and Key 2013).

Pork processors use complex production contracts with hog producers, according to which hog producers raise (feed and finish) pigs/hogs for pork processors in exchange for a fee. Consequently, pork processors make decisions that affect hog quantities produced by hog producers under these contracts. Hog producers do not own pigs/hogs they raise for pork processors. Production contracts specify responsibilities of pork processors and hog producers in great details (Swinton and Martin 1997; McBride and Key 2013; Lawrence et al. 2019). Typically, under production contracts pork processors are responsible for providing pigs, feed, veterinary and medical supplies and services, and transportation of pigs to and from the farms, and they also determine production management practices. Hog producers are responsible for providing hog housing facilities, land, labor, utilities, operating expenses, and following production management practices determined by the processor.

The hog quantity produced each year affects hog prices, which are input prices or costs for pork processors who purchase hogs from hog producers using the spot market or marketing contracts. Consistent with agricultural production and price cycle, in the years of small hog production, hog prices tend to be high, and in the years of large hog production, hog prices tend to be low. The hog production and price cycle lasts approximately 3 to 4 years (Kohls and Uhl 2002; Norwood and Lusk 2008), and it can be briefly described as follows. Assume that in the past year hog quantity available in the market was small and hog prices were high. In the current year, hog producers who are already in business plan to increase hog quantity produced by increasing (expanding) their herd sizes, and some hog producers re-enter the industry looking to capture existing profits. To increase their herd size, hog producers must retain female hogs from the market for breeding purposes, which further decreases the current quantity of hogs marketed and consequently further pushes the current hog price up.

In the next few years, after the expansion, the quantity of hogs supplied to the market increases, which will decrease hog prices. In response to low hog prices, there will be a decrease in hog quantity produced and marketed. Many hog producers will decrease their herd sizes in response to low hog prices. Some hog producers will liquidate their herds by exiting the industry. This contraction in hog production would lead to higher hog prices in the future.

Feed (corn and soybean meal) is the major input used in hog production. Feed costs account for more than 65 percent of all pork production expenses (Pork Checkoff 2022b). A dramatic increase in feed prices, coupled with the effect of hog production and price developments, adversely affected the profitability of pork processors in 2009 (Giamalva 2014; *In Re Pork Antitrust Litigation* 2020). The prices of corn and soybean meal, the two major feed types used in hog production, started increasing dramatically in 2008 (Becker 2008; Schnepf 2008). Pork processors, who used production contracts with hog producers, had to pay higher feed prices. Pork processors, who purchased their hogs using the spot market and/or marketing contracts, had to pay higher hog prices, which were due to higher feed prices.

The largest pork processors implemented a series of production cuts at various stages of the pork supply chain beginning in 2009 to decrease the quantities of pork produced in the period of increasing feed prices and weakening demand to maintain a viable profitability level and to avoid financial losses (Giamalva 2014; *In Re Pork Antitrust Litigation* 2020). The combined market share of the largest pork

[9] Under a marketing contract, hog producers own the hogs they raise, to be sold to processors later. Consequently, hog producers are responsible for making production and marketing decisions.

processors, who implemented production cuts, was approximately 80 percent (*In Re Pork Antitrust Litigation* 2020).

- At the breeding stage, pork processors decreased the size of breeding stocks and decreased the number of female hogs. Because of the increasing use of production contracts, pork processors had some control over the breading stage of the pork supply chain.
- At the production stage, pork processors increased the use of production contracts, by which they had increased control over the quantity of hogs procured under these contracts and consequently over the quantity of pork they produced.
- At the production stage, pork processors decreased the number of hogs by implementing partial liquidations of their herds.
- At the processing stage, pork processors controlled hog slaughter rates and decreased the utilization of plant capacity (i.e., decreased the quantity of hogs processed at a plant).
- Pork processors increased pork export volume, which decreased the quantity of pork available for the domestic market.

The largest pork processors periodically made public statements regarding their intent to implement production cuts. The following excerpts are three examples of these statements.

(1) *"In May 2009, …, the CEO and President of Smithfield, stated: In terms of chronology of how I say we proactively managed this business, in February of last year—**February of '08**, not February of '09—**we made the decision with the over-supply of livestock to take the leadership position and start reducing our sow herds because we saw the overproduction and the oversupplies of the hogs into the market, which was driving our hog market down. We started a reduction of 50,000 sows and 1 million of our 18 million pigs, we started taking out of the system**"* (*In Re Pork Antitrust Litigation* 2020, paragraph 138).

(2) *"In June 2009, the CEO of Smithfield stated that the **current cuts were not enough and more were needed to 'fix' the hog industry and that '[s]omebody else has got to do something'**: One of the things that we're doing is managing what you can do and the 3 percent relates to one of our operations and it's our—I'll tell you, it's our Texas operation that sells pigs to Seaboard. Seaboard knows that. . . . **That 3 percent, let me say that, our 3 percent will not fix the hog industry. That part I'm confident of. Somebody else has got to do something.** We cut 13 percent. The first 10 percent didn't fix it. I don't think us going from 10 to 13 is going to fix the hog business"* (*In Re Pork Antitrust Litigation* 2020, paragraph 140).

(3) *"In August of 2009, Tyson Foods, Inc. Chief Operating Officer, …, confirmed: Hog supplies will be down in Q4 year over year but still adequate. **We do expect to see liquidation accelerate and pork production decrease into 2010 and beyond to improve producer profitability.** We will continue to watch forward hog supplies to drive more exports, monitor demand, focus on cost, mix, and pricing to generate revenue"* (*In Re Pork Antitrust Litigation* 2020, paragraph 142).

Table 4 presents data on yearly pork production, wholesale prices, percentage changes in the production and price, and price flexibilities for the period of 2000–2017 (Figure 3 depicts production and prices).[10] In the pre-production control period (2000–2008), all percentage changes in pork production are positive, indicating that in this period pork production was increasing.[11] This consistent increase in quantity of pork produced each year might have contributed to the oversupply (overproduction) of pork and low wholesale pork prices not profitable for pork processors.

Table 4. The U.S. Pork Production, Wholesale Prices, and Price Flexibilities, 2000—2017

Year	Pork Production (Q)	Wholesale Pork Price (P)	Change in Pork Production	Change in Pork Price	Pork Price Flexibility
	Million pounds	Cents per pound	Percent	Percent	$\frac{\%\ change\ in\ P}{\%\ change\ in\ Q}$
Pre-Production Control Period (Pre-PC Period): 2000–2008					
2000	18,952.0	64.07			
2001	19,160.0	66.83	1.10	4.31	3.9
2002	19,685.0	53.49	2.74	-19.96	**-7.3**
2003	19,966.0	58.87	1.43	10.05	7.0
2004	20,529.0	73.53	2.82	24.90	8.8
2005	20,705.0	69.84	0.86	-5.02	**-5.9**
2006	21,073.5	67.62	1.78	-3.17	**-1.8**
2007	21,962.1	67.54	4.22	-0.13	**-0.03**
2008	23,366.6	69.24	6.40	2.52	0.4
Production Control Period (PC Period): 2009–2017					
2009	23,020.4	58.13	-1.48	-16.05	10.8
2010	22,455.5	81.25	-2.45	39.78	**-16.2**
2011	22,775.4	93.69	1.42	15.31	10.7
2012	23,267.9	84.54	2.16	-9.77	**-4.5**
2013	23,204.2	91.69	-0.27	8.45	**-30.9**
2014	22,858.0	110.10	-1.49	20.08	**-13.5**
2015	24,516.8	78.96	7.26	-28.28	**-3.9**
2016	24,956.6	78.36	1.79	-0.77	**-0.4**
2017	25,597.6	84.02	2.57	7.22	2.8

Note: Data source for yearly pork production and monthly pork prices is USDA, Economic Research Service (2022a, 2022b). Yearly prices are calculated by the author using monthly prices reported in USDA, Economic Research Service (2022b).

[10] Nominal wholesale prices of pork (these are actual market prices that are not adjusted for inflation) are used in the empirical analysis presented in the case study. A discussion of the rationale for using nominal wholesale prices as opposed to real wholesale prices is discussed in Appendix I. The latter also presents a descriptive statistical analysis of real wholesale prices.

[11] The total pork production each year is affected by the number of hogs slaughtered and the weight of each hog.

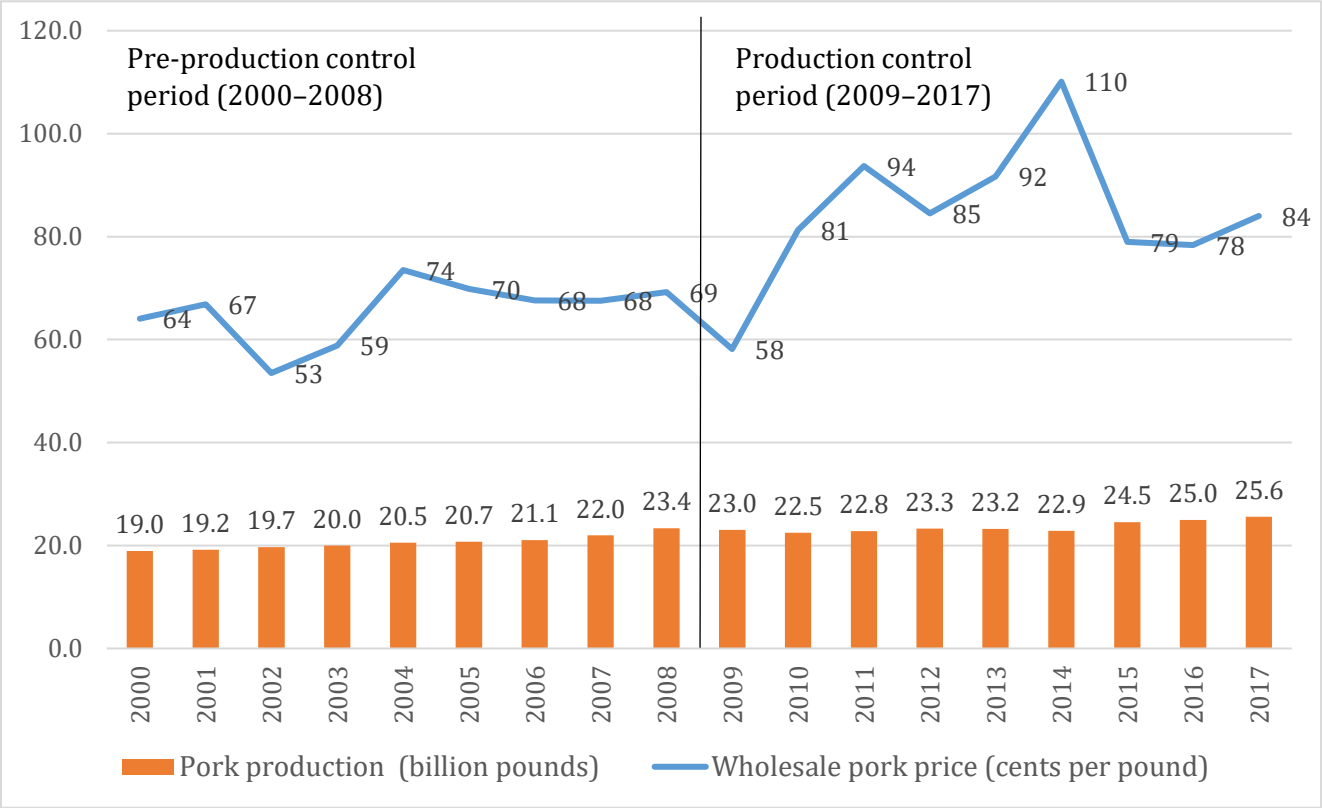

Figure 3. The U.S. Pork Production and Wholesale Prices (Yearly Data), 2000–2017

Data source for yearly pork production and monthly wholesale prices is USDA, Economic Research Service (2022a, 2022b).
Note: Yearly prices are calculated by the author using monthly prices reported in USDA, Economic Research Service (2022b).

In the production control period (2009–2017), the percentage changes in pork production are both positive and negative. The decreases in pork production are in the range of -0.27 percent in 2013 to -2.45 percent in 2010. These decreases in yearly production might reflect the effects of production cuts, given that pork processors who implemented production cuts controlled approximately 80 percent of the wholesale pork market. The increases in pork production are in the range of 1.42 percent in 2011 to 7.26 percent in 2015. The percentage increases in pork production might also reflect the effects of production cuts, in which case the growth of production was slowed down.

The pork price flexibilities vary in magnitude over time.[12] The majority of price flexibilities with the expected negative sign are in the range of -1 to -7. For example, a price flexibility calculated for 2012 is -4.5, indicating that a 1 percent increase in pork production in the period of 2011–2012 caused a 4.5 percent decrease in the wholesale price of pork. The absolute value of the majority of calculated pork price flexibilities is greater than one, reflecting inelastic demand for pork. Because a percentage change in pork price is greater than a percentage change in pork quantity, pork processors would benefit from decreasing

[12] Price flexibilities are elasticities associated with price-dependent (inverse) demand functions (Moore 1919; Houck 1965; Hudson 2007). Price flexibility indicates a percentage increase (decrease) in product price, which follows a 1-percent decrease (increase) in product quantity demanded. Theoretically, price flexibilities are expected to be negative. The positive values for price flexibilities reported for selected years are not as expected. These positive values may reflect the effects of changes in a variety of factors affecting prices and quantities of pork: prices and quantities of products-substitutes (chicken and beef), consumer income, production costs (for example, feed prices, hog prices, and fees paid to contract hog growers), new production technologies leading to increasing productivity (increasing hog weight). Appendix II discusses price flexibilities in greater detail.

the pork quantity produced even by a small percent, which would cause the wholesale pork price to increase by a greater percent.

4 Theoretical Frameworks

This section presents a graphical analysis of economic models explaining the profit-maximizing behavior of industries exercising seller market power and perfectly competitive industries, which may be used to evaluate conduct and performance of the broiler and pork industries in the analyzed setting.[13] In the analysis presented in this section it is assumed that broiler and pork processors are integrators, who use production contracts according to which they are responsible for incurring feed costs.

4.1 The U.S. Broiler Chicken and Pork Industries as Classic Oligopolies

Based on the number of firms operating in the U.S. broiler and pork industries and other industry characteristics (product homogeneity, inelastic demand, and high barriers to entry), these industries are classic oligopolies—market structures with a relatively small number of sellers. To understand their seller market power, oligopolies are evaluated relative to a perfectly competitive industry.

Figure 4 is a graphical representation of an economic model explaining the profit-maximizing behavior of firms in perfectly competitive industries and industries with seller market power (oligopoly and monopoly). The inverse demand curve labeled as "P" is a graphical representation of the inverse (price-dependent) demand function at the wholesale (processing) stage of the broiler and pork supply chains. The marginal cost curve labeled as "MC" is a graphical representation of a constant marginal cost function. The processors make decisions on the output quantity to produce (output: broiler chickens and pork products). The output price is a function of the output quantity.

To maximize its profit, an oligopolistic industry produces output quantity (Qo), which is smaller than output quantity produced by a perfectly competitive industry (Qc). The output price in the oligopolistic industry (Po) is higher than the output price in a perfectly competitive industry (Pc), and the oligopolistic industry profit is positive (Po-MC > 0). If firms operating in the oligopolistic industry form an output price-fixing cartel (i.e., engage in a price-fixing conspiracy),[14] to maximize their *joint* profit, they would aim to decrease output quantity (Qo) possibly to output quantity produced by a monopoly (Qm). As a result, the oligopoly price (Po) would approach the monopoly price (Pm), and the industry profit increases by Pm-Po in $ per unit and by (Pm-Po)*Qm in total $, which is a cartel overcharge.[15]

The cartel overcharge expressed in total $ is the shaded rectangle in Figure 4. The cartel overcharge is the basis for damages that direct buyers of broilers and pork products aim to recover during antitrust litigations.[16] In summary, the cartel effects on buyers of the cartelized product are a decrease in the product quantity available in the market, an increase in this product price, and a

[13] The teaching note's Appendix I presents mathematical formulations of the profit-maximization problems for a monopolist, an oligopolist, and a perfectly competitive firm, which can be used if this case study is used in the upper level undergraduate and graduate courses. Alternatively, standard profit-maximization problems for monopoly and oligopoly explained in classic textbooks in the areas of microeconomics, industrial organization, and agricultural markets and prices can be used to illustrate mathematical formulations of these economic models (Besanko and Braeutigam 2002; Carlton and Perloff 2005; Hudson 2007; Norwood and Lusk 2008).

[14] A cartel is a group of firms, who produce and sell the same or similar products (the firms are competitors), which aims to affect product quantities and/or prices to increase the joint profit of cartel participants. Cartels are typically organized in concentrated (oligopolistic) industries. A classic output price-fixing cartel would aim to act as a multi-plant monopolist (Besanko and Braeutigam 2002).

[15] It is often assumed that oligopolists have incentives to collude to increase their joint profit. Theoretically, an oligopolistic conduct can result in a variety of market outcomes (output price-quantity combinations) ranging from perfect competition to an oligopoly and even to a monopoly, which can be reached without firms having agreements violating Section 1 of the Sherman Act (Baker 1993; Besanko and Braeutigam 2002; Carlton and Perloff 2005; Hovenkamp 2005).

[16] Buyers purchasing broilers and pork products directly from processors are entitled to recover treble damages under the Clayton Act (1914), a federal law.

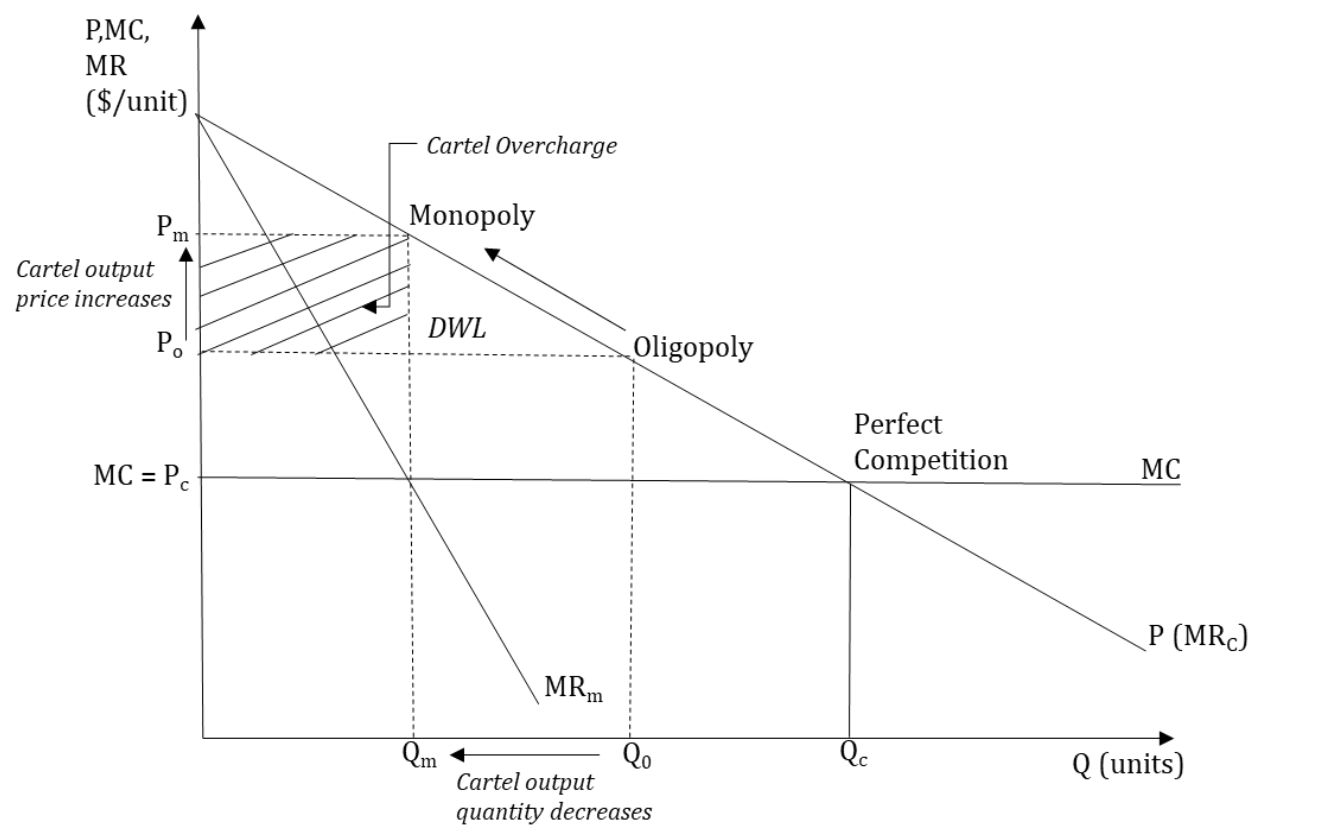

Figure 4. The U.S. Broiler and Pork Industries as Classic Oligopolies Acting as Output Price-Fixing Cartels: Output Quantity and Output Price Effects

deadweight loss. The latter is the "DWL" triangle in Figure 4. Because of the deadweight loss there are buyers who do not purchase the product because of higher prices.

4.2 The U.S. Broiler Chicken and Pork Industries as Perfectly Competitive Industries Facing Increasing Marginal Cost

A description of the nature of agricultural supply and profitability issues in the broiler and pork industries presented in the previous section may suggest that these industries behaved as perfectly competitive industries.

Figure 5 is a graphical representation of an economic model explaining the profit-maximizing behavior of a perfectly competitive industry facing increasing marginal cost. The original scenario presented in Figure 5 is the one for the period prior to the implementation of production cuts in the broiler and pork industries ("Perfect Competition" at the intersection of the inverse demand and marginal cost curves). The output price-quantity combination corresponding to the original scenario is Qc and Pc, and the industry profit is zero (Pc = MC or Marginal Profit = Pc – MC = 0).

The implementation of production cuts by broiler and pork processors coincided with a dramatic increase in feed prices (corn and soybean meal prices). The feed price is a major variable cost component for broiler and pork processors. An increase in feed prices would represent an upward parallel shift of the marginal cost curve: this is a new scenario with the increased marginal cost. The original marginal cost curve labeled as MC in Figure 5 shifts upward to become the new marginal cost curve labeled as MC^{new}. Assuming the output price-quantity relationship (demand) does not change, an increase in

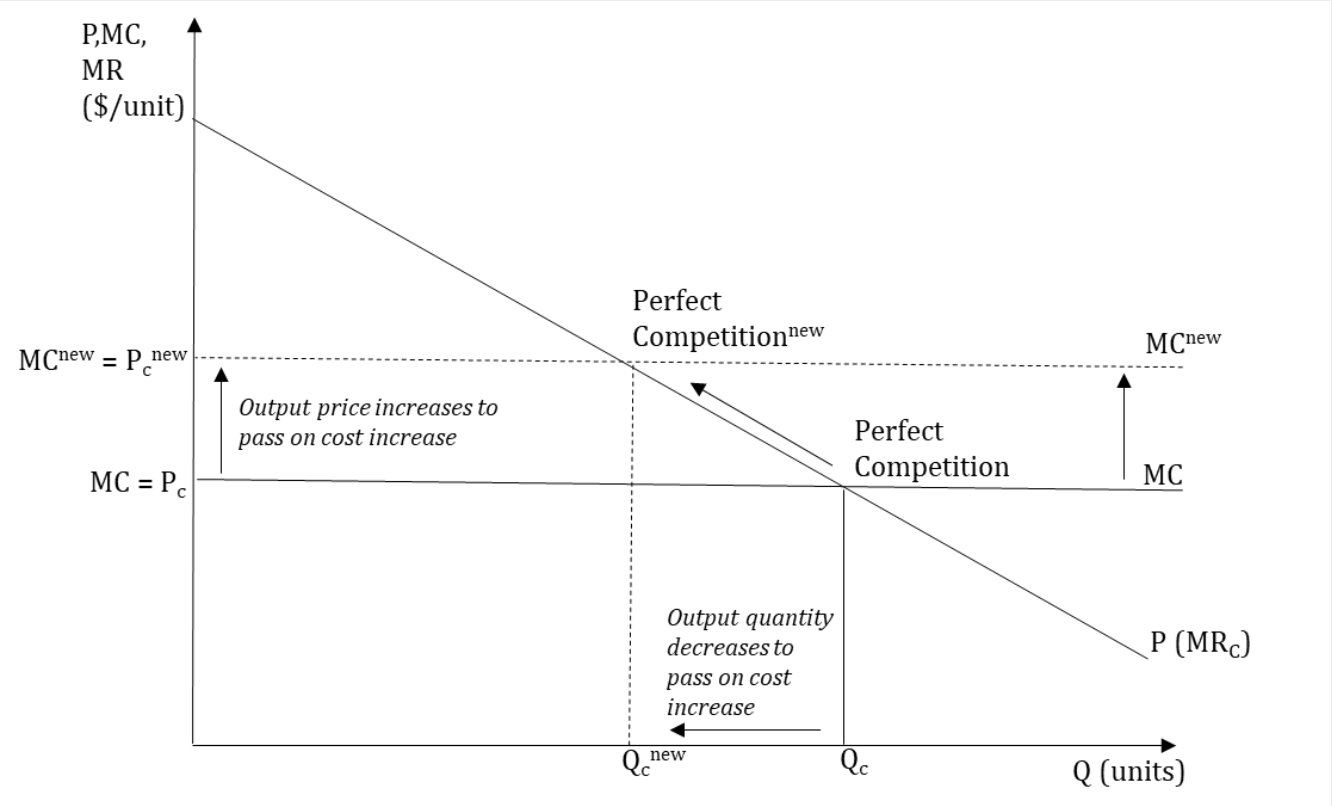

Figure 5. The U.S. Broiler and Pork Industries as Perfectly Competitive Industries Facing Increasing Marginal Cost (Increasing Feed Prices): Output Quantity and Output Price Effects

marginal cost would require processors to decrease output quantity produced to maintain the profitability level of the original perfectly competitive industry scenario. The processors have to decrease output quantity produced to pass the cost increase on to buyers, which would result in a higher output price. Consequently, the processors decrease output quantity from Qc to Qc^{new}, and output price increases from Pc to Pc^{new}. The overall industry profit in the new scenario is zero ($Pc^{new} = MC^{new}$ or Marginal Profit = $Pc^{new} - MC^{new} = 0$).

Figure 5 indicates that the industry profitability is determined by the output price, marginal cost, and output quantity. If broiler and pork processors do not decrease output quantity in response to the increased marginal cost, they would be in an agricultural oversupply (overproduction) scenario, where the original output price Pc is below the new marginal cost MC^{new} (at the original scenario's output quantity Qc). Consequently, the industry profit would be negative, because at the original output quantity Qc the inverse demand curve is below the new marginal cost curve ($Pc < MC^{new}$ or Marginal Profit = $Pc - MC^{new} < 0$).

Figure 6 is a modified version of Figure 5, where the Figure 5's output price and quantity corresponding to the original scenario are labeled as the ones corresponding to the oversupply scenario, Qo and Po. In the oversupply scenario, the profit is negative (at Qo, Marginal Profit = $Po - MC^{new} < 0$); broiler and pork processors incur losses. Figures 5 and 6 may explain economic rationale for implementing production cuts in the broiler and pork industries, assuming that they behave as perfectly competitive industries.

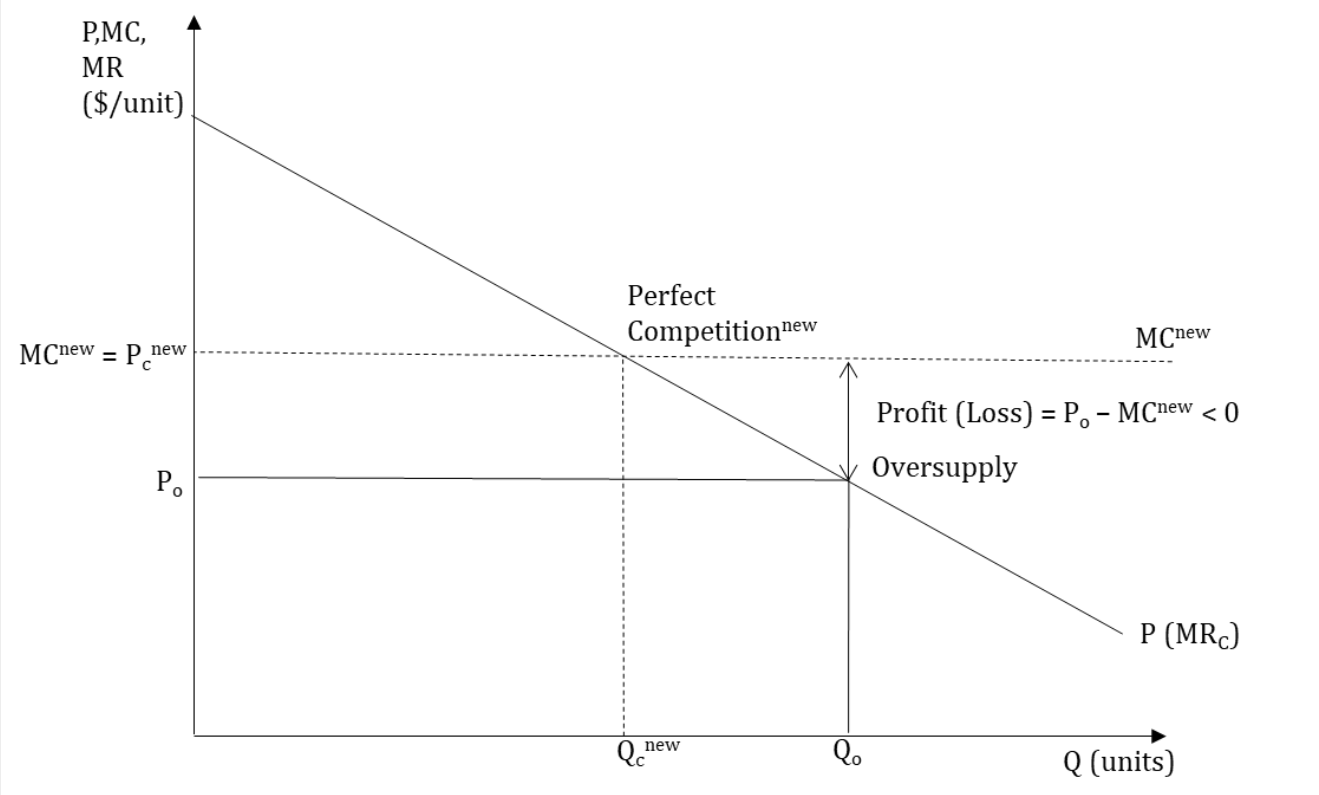

Figure 6. The U.S. Broiler and Pork Industries as Perfectly Competitive Industries Facing Increasing Marginal Cost (Increasing Feed Prices): Output Quantity, Output Price, and Industry Profit (Loss) in the Oversupply Scenario

5 Market and Price Analysis

This section presents a descriptive statistical analysis of the economic variables characterizing market and price behavior in the U.S. broiler and pork industries in the two periods of interest: the pre-production control period (Pre-PC period) and the production control period (PC period).[17] The analyzed variables include product quantities (production, domestic consumption, and export), wholesale prices, and margins (or corresponding indices). The analysis is conducted at the wholesale (processing) stage of the broiler and pork supply chains. The variables are collected from USDA Economic Research Service databases (U.S. Department of Agriculture, Economic Research Service 2022a, 2022b, 2022c).[18] The analysis objective is to identify and evaluate changes in the level and volatility of the analyzed economic variables between the two periods of interest by calculating their averages and coefficients of variation for the two periods,[19] as well as changes in the averages and coefficients of variation between the two

[17] In the U.S. broiler industry, the Pre-PC period is 2000–2007, and the PC period is 2008–2015. The beginning of the PC period is the beginning date of the alleged price-fixing conspiracy stated in *In Re Broiler Chicken Antitrust Litigation* (2019). The end of the PC period is the year prior to the year when antitrust lawsuits were filed against the largest broiler processors. The U.S. pork industry: the Pre-PC period is 2000–2008, and the PC period is 2009–2017. The beginning of the PC period is the beginning date of the alleged price-fixing conspiracy stated in *In Re Pork Antitrust Litigation* (2020). The end of the PC period is the year prior to the year when antitrust lawsuits were filed against the largest pork processors. The Pre-PC period in the case of both industries is selected such that its length is equal to the PC period length.

[18] The teaching note's Appendix II provides a detailed description of economic variables and data sources.

[19] Coefficient of variation (CV) is selected to measure the volatility of the analyzed variables. While there are other measures of volatility available, for example standard deviation and variance, an advantage of the coefficient of variation is that it measures

periods. The evaluation of changes in the volatility of the analyzed economic variables would provide evidence on whether by implementing agricultural supply control practices the broiler and pork industries were able to effectively manage agricultural supply and price volatility to stabilize their agricultural production conditions.

5.1 U.S. Broiler Chicken Industry

Table 5 presents descriptive statistics on broiler production, export, and availability for domestic consumption in the Pre-PC and PC periods.[20] The yearly average broiler production is 33,127 million pounds in the Pre-PC period, and it increases to 37,100 million pounds in the PC period (or by ___ percent).[21] The yearly average broiler export is 5,162 million pounds in the Pre-PC period, and it increases to 6,970 million pounds in the PC period (or by ___ percent).

The yearly average quantity of broiler meat available for domestic consumption is 27,833 million pounds in the Pre-PC period, and it increases to 30,016 million pounds in the PC period (or by ___ percent). The yearly average quantity of broiler meat available per capita is 95 pounds in the Pre-PC period, and it increases slightly to 96 pounds in the PC period (or by ____ percent). As indicated by

Table 5. The U.S. Broiler Chicken Industry: Yearly Broiler Production, Export, and Availability, 2000—2015

Average/ Coefficient of Variation (CV)	Broiler Production	Broiler Export	Broiler Availability	Broiler Availability per Capita
	Million pounds	Million pounds	Million pounds	Pounds
Pre-Production Control Period (Pre-PC Period): 2000–2007				
Average	33,127	5,162	27,833	95
CV	0.06	0.08	0.07	0.05
Production Control Period (PC Period): 2008–2015				
Average	37,100	6,970	30,016	96
CV	0.04	0.05	0.05	0.03
Change: PC Period, Relative to Pre-PC Period				
Average	3,973	_____	2,183	_____
Average (percentage change)	12.0	_____	7.8	_____
CV	-0.03	_____	-0.02	_____
CV (percentage change)	-43	_____	-32	_____

Source: USDA, Economic Research Service (2022a).
Note: Students should calculate changes in the averages and coefficients of variation for broiler export and availability per capita and record their answers in cells with missing answers (Question 6.1).

changes in the coefficients of variation, the volatility of all quantity-related variables decreases in the PC period, as compared with the Pre-PC period.

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the standard deviation relative to the mean of the analyzed variable: $CV = \frac{Standard\ Deviation}{Mean}$. The coefficient of variation can also be expressed in the percentage form.

[20] The results reported in Tables 5–8 were generated in Excel. If selected calculations are reproduced using a calculator, results might be slightly different than those reported here.

[21] Tables 5–8 have cells with missing answers. Students should calculate changes in the averages and coefficients of variation and record their answers in the cells with missing answers. After relevant calculations are performed and the answers are recorded in the tables, students should record *percentage* changes in the averages of the analyzed variables between the two periods in the parentheses in the text of the case study (Sections 5.1 and 5.2). Alternatively, instructors might prefer to share with students Tables 5–8 with all answers recorded or an Excel file with relevant calculations, which are included in the teaching note.

Table 6 presents descriptive statistics on the three indices characterizing changes in the broiler feed costs, wholesale price, and margin (wholesale price minus feed costs) in the two periods of interest. Figure 1 depicts these three indices for the period of 2001–2017.

Table 6. The U.S. Broiler Chicken Industry: Monthly Feed Costs Index, Wholesale Price Index, and Wholesale Price Minus Feed Costs (Margin) Index, 2001—2015

Average/Coefficient of Variation (CV)	Feed Costs per Pound *Index*	Wholesale Price *Index*	Wholesale Price Minus Feed Costs *Index*
Pre-Production Control Period (Pre-PC Period): 2001–2007			
Average	109.75	115.40	117.40
CV	0.12	0.15	0.17
Production Control Period (PC Period): 2008–2015			
Average	183.46	137.77	121.61
CV	0.17	0.11	0.15
Change: PC Period Relative to Pre-PC Period			
Average	_____	_____	4
Average (percentage change)	_____	_____	4
CV	_____	_____	-0.02
CV (percentage change)	_____	_____	-13.66

Source: USDA, Economic Research Service (2022b).
Note: Students should calculate changes in the averages and coefficients of variation for feed costs index and wholesale price index and record their answers in cells with missing answers (Question 6.2).

The monthly average feed costs index is 110 in the Pre-PC period, and it increases to 183.5 in the PC period (or by ____ percent). The monthly average wholesale price index is 115.4 in the Pre-PC period, and it increases to 138 in the PC period (or by _____ percent). The monthly average margin index is 117.4 in the Pre-PC period, and it increases to 121.6 in the PC period (or by _____ percent). As indicated by changes in the coefficients of variation, the volatility of the feed costs index increases, but the volatility of the wholesale price and margin indices decreases in the PC period, as compared with the Pre-PC period.

Table 7 presents descriptive statistics on the wholesale broiler price for the two periods of interest. The monthly average wholesale broiler price is $0.64 per pound in the Pre-PC period, and it increases to $0.79 per pound in the PC period (or by _____ percent). As indicated by the change in the coefficient of variation, the volatility of this price decreases by 32 percent in the PC period, as compared with the Pre-PC period.

5.2 U.S. Pork Industry

Table 8 presents descriptive statistics on pork production, export, and availability for domestic consumption for the two periods of interest. The yearly average pork production is 20,600 million pounds in the Pre-PC period, and it increases to 23,628 million pounds in the PC period (or by _____ percent). The yearly average pork export is 2,424 million pounds in the Pre-PC period, and it increases to 4,983 million pounds in the PC period (or by _____ percent). The yearly average quantity of pork available

Table 7. The U.S. Broiler Chicken and Pork Industries: Monthly Wholesale Broiler Price, Wholesale Pork Price, and Pork Farm-to-Wholesale Margin, 2000—2017

Average/Coefficient of Variation (CV)	Wholesale Broiler Price	Wholesale Pork Price	Pork Farm-to-Wholesale Margin
	Cents per pound	Cents per pound	Percent of wholesale value
Pre-Production Control Period (Pre-PC Period)	***2000–2007***	***2000–2008***	
Average	64.26	65.67	32.48
CV	0.16	0.13	0.16
Production Control Period (PC Period)	***2008–2015***	***2009–2017***	
Average	78.69	84.53	35.13
CV	0.11	0.18	0.23
Change: PC Period Relative to Pre-PC Period			
Average	14.43	18.86	_____
Average (percentage change)	22	29	_____
CV	-0.05	0.05	_____
CV (percentage change)	-32	40	_____

Source: USDA, Economic Research Service (2022b, 2022c).
Note: Students should calculate changes in the average and coefficient of variation for pork farm-to-wholesale margin and record their answers in cells with missing answers (Question 7.2).

Table 8. The U.S. Pork Industry: Yearly Pork Production, Export, and Availability, 2000—2017

Average/Coefficient of Variation (CV)	Pork Production	Pork Export	Pork Availability	Pork Availability per Capita
	Million pounds	Million pounds	Million pounds	Pounds
Pre-Production Control Period (Pre-PC Period): 2000–2008				
Average	20,600	2,424	19,013	65
CV	0.07	0.44	0.02	0.02
Production Control Period (PC Period): 2009–2017				
Average	23,628	4,983	19,370	61
CV	0.05	0.10	0.05	0.04
Change: PC Period, Relative to Pre-PC Period				
Average	3,028	_____	358	_____
Average (percentage change)	14.7	_____	1.9	_____
CV	-0.02	_____	0.03	_____
CV (percentage change)	-31	_____	161	_____

Source: USDA, Economic Research Service (2022a).
Note: Students should calculate changes in the averages and coefficients of variation for pork export and availability per capita and record their answers in cells with missing answers (Question 7.1).

for domestic consumption is 19,013 million pounds in the Pre-PC period, and it increases to 19,370 million pounds in the PC period (or by _____ percent). The yearly average quantity of pork available per capita is 65 pounds in the Pre-PC period, and it decreases to 61 pounds in the PC period (or by _____ percent). As indicated by changes in the coefficients of variation, the volatility of pork production and export decreases, but the volatility of pork quantity available for domestic consumption increases in the PC period, as compared with the Pre-PC period.

Table 7 presents descriptive statistics on wholesale pork price and farm-to-wholesale margin for the two periods of interest. The monthly average wholesale pork price is $0.66 per pound in the Pre-PC period, and it increases to $0.85 per pound in the PC period (or by _____ percent). As indicated by the change in the coefficient of variation, the volatility of this price increases by 40 percent in the PC period, as compared with the Pre-PC period. The monthly average pork farm-to-wholesale margin is 32.5 percent of the wholesale value ("price") of pork in the Pre-PC period, and it increases to 35.1 percent in the PC period (or by ____ percent). As indicated by the change in the coefficient of variation, the volatility of this margin increases by 40 percent in the PC period, as compared with the Pre-PC period.

5.3 Market and Price Analysis: Summary

The empirical evidence indicates that in the PC period the yearly average total quantities of broilers and pork produced in the country increased by approximately 12 percent and 15 percent, respectively. However, an analysis of yearly changes in the quantities of broilers and pork produced indicates that while in the pre-PC period there was a consistent increase in the yearly production of broilers and pork, in the PC period the decreases in the yearly production of broilers and pork in selected years were observed (Tables 3 and 4; Figures 2 and 3). While the implementation of production cuts on average did not decrease the quantities of broilers and pork produced in the PC period, it might have decreased the production's growth rate in both industries. Had the broiler and pork industries not implemented production cuts, the increases in production would have been larger, potentially leading to the oversupply problem, low wholesale prices, and financial losses for broiler and pork processors.

The yearly average product quantity available for domestic consumption per capita increased by 0.7 percent in the broiler industry and decreased by 5.5 percent in the pork industry in the PC period. This is because the export of both types of meat increased, and there was an increase in the U.S. population in this period. While the yearly average export of broilers increased by 35 percent, the yearly average export of pork increased by 105.6 percent. A substantial increase in the export of broilers and pork decreased quantities of these products available for domestic consumption in the PC period.

In the PC period, as compared with the prior period, the volatility of broiler production, export, and quantities available for domestic consumption decreased, the volatility of pork production and export decreased, and the volatility of quantities of pork available for domestic consumption increased. The decreases in the volatility of broiler and pork production may reflect the effects of agricultural supply control practices, leading to more stable agricultural production conditions, which may have had a positive effect on the profitability of broiler and pork processors.

A smaller quantity of product available for domestic consumption would generally increase this product price. The monthly average wholesale prices of broilers and pork increased by 22 percent and 29 percent, respectively, in the PC period, as compared with the prior period. However, these price increases are likely to reflect increases in the costs of feed (corn and soybean meal), which broiler and pork processors passed on to buyers of their products to avoid the oversupply of broilers and pork and low wholesale prices. For example, in the broiler industry, while the feed costs index increased by 67 percent in the PC period, the wholesale price index increased only by 19 percent. The feed costs index increase was about three times the wholesale price index increase. The wholesale price minus feed costs (margin) index in the broiler industry increased only by 4 percent. While the volatility of the wholesale broiler price and margin indices decreased, the volatility of the wholesale pork price and farm-to-wholesale

margin increased in the PC period.

6 Antitrust Issues

Beginning in 2016, buyers of broiler chickens, and beginning in 2018, buyers of pork products started filing class action antitrust lawsuits against the largest broiler and pork processors in the country. The buyers alleged that by implementing production cuts and publicly communicating their intentions to implement these production cuts, the processors engaged in unlawful conspiracies with the purpose of fixing, increasing, and stabilizing prices of broiler chickens and pork products paid by various participants in the broiler and pork supply chains (wholesalers, retailers, restaurants, institutional buyers, and final consumers) and violated Section 1 of the Sherman Act (1890). The buyers claimed that they had to pay higher prices for broiler chickens and pork products and were overcharged.

Section 1 of the Sherman Act prohibits contracts, combinations, and conspiracies in restraint of trade in interstate commerce. Price-fixing agreements (cartels or conspiracies) among competitors (firms producing and selling the same or similar products) are examples of the restraints of trade that are most damaging to the market. Price-fixing agreements aim to increase, decrease, or fix (stabilize) product prices, and can be verbal, written, or inferred from the conduct of firms (Federal Trade Commission 2022a). The market effects of a typical output price-fixing cartel are a decrease in the product quantity available in the market, an increase in the product price buyers have to pay, a welfare transfer from buyers to producers (overcharge), and a deadweight loss, due to which there are buyers who do not purchase the product because of higher prices (Figure 4).

In antitrust litigations involving violations of Section 1 of the Sherman Act, plaintiffs must prove the presence of an agreement among competitors violating this section. Direct evidence of this agreement is usually not available, and the agreement must be established using circumstantial evidence.[22] Buyers of broilers and pork products (plaintiffs in the lawsuits) argued that the following conduct of the largest broiler and pork processors constituted the agreements violating section 1 of the Sherman Act.

First, the largest broiler and pork processors publicly communicated their intentions to implement production cuts. Second, the processors shared (exchanged) private, competitor-sensitive information (information related to product quantities, prices, costs, and profit) for the purpose of benchmarking the performance of individual firms.[23] The information exchanges were accomplished by employing a third party, Agri Stats. This firm gathered competitor-sensitive supply and price data from broiler and pork processors, processed these data, and shared the results with the processors.

Private parties (individuals and firms) pursue violations of Section 1 of the Sherman Act by filing civil (private) lawsuits. Direct buyers file private lawsuits under the Clayton Act (a federal law), and they are entitled to recover treble damages (three times the overcharge). Indirect buyers file private lawsuits under the states' antitrust, consumer protection, and unjust enrichment laws and are entitled to recover damages in selected states where these laws exist. The U.S. Department of Justice (DOJ) can file both civil and criminal lawsuits for violations of the Sherman Act. The criminal penalties currently include $100 million for corporations, $1 million for individuals, and up to 10 years in prison for individuals (Federal Trade Commission 2022b).

[22] The circumstantial evidence includes the presence of a parallel conduct of the defendants (for example, parallel pricing) and additional plus factors. Some of the plus factors must support the parallel conduct, and some of the plus factors must indicate the presence of market structures and business practices facilitating collusion. Proving an agreement among competitors violating Section 1 of the Sherman Act represents the main challenge for plaintiffs during antitrust litigations (Baker 1993; Hovenkamp 2005).

[23] Sharing competitor-sensitive information (information on prices, quantities, costs, and customers) may have anticompetitive effects and is likely to raise competition concerns (Bloom 2014). Sharing competitor-sensitive information may be used as a factor when a price-fixing agreement violating Section 1 of the Sherman Act is to be inferred from the firms' conduct.

The class action antitrust lawsuits filed by buyers purchasing broilers and pork directly and indirectly from the largest broiler chicken and pork processors are private (civil) lawsuits. Some of these lawsuits are in the process of being settled. Table 9 summarizes settlements reached by some of the broiler and pork processors with private plaintiffs as of the beginning of 2022.

In June 2019, the DOJ opened its own criminal investigation of price-fixing, bid-rigging, and other anticompetitive conduct in the broiler industry. In June 2020, four executives, and in October 2020, six executives of the largest broiler processors were indicted on price-fixing and bid-rigging charges facing potentially 10 years in prison and up to $1 million in fines (Byington 2021; U.S. Department of Justice 2020a, 2020b). The indicted executives exchanged price information for broiler chickens using text-messages, e-mails, and phone calls.

As a result of the DOJ investigation in the broiler industry, one of the largest broiler processors, Pilgrim's Pride (owned by JBS S.A.), pled guilty and was sentenced to pay a criminal fine of approximately $107 million for participating in a nationwide conspiracy to fix prices and rig bids for broiler chicken products (U.S. Department of Justice 2021).

Table 9. Broiler Chicken and Pork *Private* Antitrust Litigations: Settlements

Date	Defendant	Settlement
Broiler Chicken Antitrust Litigation		
Lawsuit with direct purchasers		
July 2017	Fieldale Farms	$2.25 million
December 2019	Peco Foods	$5.15 million
	George's	$4.25 million
	Amick Farms	$3.95 million
January 2021	Tyson Foods	$80 million
	Pilgrim's Pride (JBS USA)	$75 million
August 2021	Mar-Jac Poultry	$7.975 million
September 2021	Harrison Poultry	$3.3 million
	Direct purchasers: Total	$181.875 million
Lawsuit with indirect purchasers (end-user consumers)		
October 2020–July 2021	*Indirect purchasers: Total* (Fieldale Farms, Peco Foods, George's, Tyson Foods, Pilgrim's Pride, and Mar-Jac Poultry)	$181 million
Total		***$362.875 million***
Pork Antitrust Litigation		
Lawsuit with direct purchasers		
November 2020	JBS USA	$24.5 million
June 2021	Smithfield Foods	$77.3643 million
	Direct purchasers: Total	$101.8643 million
Lawsuit with indirect purchasers		
March 2021	JBS USA	$20 million
Total		***$121.8643 million***

Note: The settlements are as of January 2022. The settlements are from Broiler Chicken Antitrust Litigation webpage (2022), Broiler Chicken Antitrust Litigation (End-User Consumer) webpage (2022), Pork Antitrust Litigation webpage (2022), and Pork Indirect Purchaser Antitrust Litigation webpage (2022).

7 Discussion and Analytical Questions

The teaching note provides additional guidance for selected discussion questions and suggested answers to all discussion and analytical questions. The teaching note also includes multiple choice questions that can be used as in-class assignments, quizzes, and exam questions.

1. Discuss structures of the U.S. broiler and pork industries by focusing on the largest firms and market concentration prior to the implementation of agricultural supply control practices. Highlight changes in market concentration in the recent 15 years.

2. Explain the production system in the U.S. broiler industry. Discuss agricultural supply control practices (production cuts) implemented by the largest broiler processors.

3. Explain the production system in the U.S. hog/pork industry. Discuss agricultural supply control practices (production cuts) implemented by the largest pork processors.

4. Using a graphical analysis, explain conduct and performance of the broiler and pork industries in the following three market situations (note that broilers and pork are "output").

    4.1. In the first situation, assume that the industries act as classic oligopolies forming output price-fixing cartels. Explain changes in output quantity and output price as the industries shift from an oligopolistic market structure to a monopolistic market structure due to an output price-fixing cartel.
    4.2. In the second situation, assume that the industries act as perfectly competitive industries facing *increasing* marginal costs represented by increasing feed prices. Explain changes in output quantity and output price as the industries respond to a marginal cost increase.
    4.3. In the third situation, assume that the industries act as perfectly competitive industries facing *decreasing* marginal costs represented by decreasing feed prices. Explain changes in output quantity and output price as the industries respond to a marginal cost decrease.

5. Familiarize yourself with the USDA Economic Research Service data sources used to collect data utilized in the empirical analysis presented in the case study (the teaching note provides additional guidance).

6. Perform a basic market and price analysis in the U.S. broiler industry to evaluate changes in the market and price behavior between the two periods of interest: the period of production control practices (PC period) and a prior period (Pre-PC period).

    6.1 Evaluate changes in the averages and coefficients of variation for the U.S. broiler industry production, export, total availability, and availability per capita between the Pre-PC and PC periods by answering the following questions. (6.1.1) Reproduce calculations of changes in the averages and coefficients of variation between the two periods for the economic variables for which answers (the calculated changes) are presented in Table 5. (6.1.2) Calculate changes in the averages and coefficients of variation between the two periods for the economic variables for which answers are not presented in Table 5 and record the calculated changes in this table. (6.1.3) Record

relevant percentage changes in the text of the case study (Section 5.1) and describe the results of your analysis.

6.2 Evaluate changes in the averages and coefficients of variation for feed cost index, wholesale price index, and wholesale price minus feed costs (margin) index between the Pre-PC and PC periods by answering the following questions. (6.2.1) Reproduce calculations of changes in the average and coefficient of variation between the two periods for the economic variable for which answers (the calculated changes) are presented in Table 6. (6.2.2) Calculate changes in the averages and coefficients of variation between the two periods for the economic variables for which answers are not presented in Table 6 and record the calculated changes in this table. (6.2.3) Record relevant percentage changes in the text of the case study (Section 5.1) and describe the results of your analysis.

7. Perform a basic market and price analysis in the U.S. pork industry to evaluate changes in the market and price behavior between the two periods of interest: the period of production control practices (PC period) and a prior period (Pre-PC period).

    7.1 Evaluate changes in the averages and coefficients of variation for the U.S. pork industry production, export, total availability, and availability per capita between the Pre-PC and PC periods by answering the following questions. (7.1.1) Reproduce calculations of changes in the averages and coefficients of variation between the two periods for the economic variables for which answers (the calculated changes) are presented in Table 8. (7.1.2) Calculate changes in the averages and coefficients of variation between the two periods for the economic variables for which answers are not presented in Table 8 and record the calculated changes in this table. (7.1.3) Record relevant percentage changes in the text of the case study (Section 5.2) and describe the results of your analysis.

    7.2. Evaluate changes in the averages and coefficients of variation for the wholesale pork price and farm-to-wholesale margin between the Pre-PC and PC periods by answering the following questions. (7.2.1) Reproduce calculations of changes in the average and coefficient of variation between the two periods for the economic variable for which answers (the calculated changes) are presented in Table 7. (7.2.2) Calculate changes in the average and coefficient of variation between the two periods for the economic variable for which answers are not presented in Table 7 and record the calculated changes in this table. (7.2.3) Record relevant percentage changes in the text of the case study (Section 5.2) and describe the results of your analysis.

8. Compare market and price behavior in the broiler and pork industries in the two periods of interest. Are the patterns of changes in quantities and prices similar or different in these two industries between the two analyzed periods? Does the market and price behavior in these industries reflect the effects of agricultural supply control practices discussed in Sections 3.1 and 3.2?

9. Reproduce calculations of broiler price flexibilities reported in Table 3 and use them to perform a price analysis and price forecast in the U.S. broiler industry. Appendix III presents a set of formulas to be used to conduct this price forecast.

    9.1. Use yearly production and price data reported in Table 3 (the data are also provided in the teaching note Excel file) to reproduce calculations of percentage changes in broiler production and price, and broiler price flexibilities reported in Table 3. Compare percentage changes in broiler production and price and the magnitude of price flexibilities in the pre-PC and PC periods. Discuss the results of your analysis.

    9.2. Assume that in the current year, the broiler industry produces 36.5 million pounds of broiler chickens, and broiler chicken price at the wholesale level is $0.71 per pound. The largest broiler processors plan to implement production cuts by decreasing broiler production by 4 percent in the next year. Assume that the broiler price flexibility is -2. Calculate (predict) broiler chicken price at the wholesale level in the next year by using a set of formulas presented in Appendix III. Show on a graph a demand curve and broiler price-quantity combinations corresponding to the two analyzed years (current year and next year). Describe the results of your analysis.

    9.3. Assume that in the current year, the broiler industry produces 39.6 million pounds of broiler chickens, and broiler chicken price at the wholesale level is $0.77 per pound. The buyers of broiler chickens filed antitrust lawsuits alleging that by implementing production control practices the largest broiler processors engaged in a price-fixing conspiracy. In the next year, the largest broiler processors will not implement any production cuts. The broiler production is expected to increase by 5 percent, because meat yield per chicken (chicken weight) has been increasing due to improvements in broiler genetics and feed efficiency. Assume that the broiler price flexibility is -3. Predict broiler chicken price at the wholesale level in the next year by using a set of formulas presented in Appendix III. Show on a graph a demand curve and broiler price-quantity combinations corresponding to the two analyzed years (current year and next year). Describe the results of your analysis.

10. Reproduce calculations of pork price flexibilities reported in Table 4 and use them to perform a price analysis and price forecast in the U.S. pork industry. Appendix III presents a set of formulas to be used to conduct this price forecast.

    10.1. Use yearly production and price data reported in Table 4 (the data are also provided in the teaching note Excel file) to reproduce calculations of percentage changes in pork production and price, and pork price flexibilities reported in Table 4. Compare percentage changes in pork production and price and the magnitude of price flexibilities in the pre-PC and PC periods. Discuss the results of your analysis.

    10.2. Assume that in the current year, the pork industry produces 23 million pounds of pork, and the pork price at the wholesale level is $0.58 per pound. The largest pork processors plan to implement production cuts by decreasing pork production by 2.5 percent in the next year. Assume that the pork price flexibility is -16. Calculate (predict) pork price at the wholesale level in the next year by using a set of formulas presented in Appendix III. Show on a graph a demand curve and pork price-quantity

combinations corresponding to the two analyzed years (current year and next year). Describe the results of your analysis.

10.3. Assume that in the current year, the pork industry produces 25.6 million pounds of pork, and the pork price at the wholesale level is $0.84 per pound. The buyers of pork filed antitrust lawsuits alleging that by implementing production control practices the largest pork processors engaged in a price-fixing conspiracy. In the next year, the largest pork processors will not implement any production cuts. The pork production is expected to increase by 5 percent, because meat yield per hog (hog weight) used to produce pork has been increasing due to improvements in hog genetics and feed efficiency. Assume that the pork price flexibility is -4. Predict pork price at the wholesale level in the next year by using a set of formulas presented in Appendix III. Show on a graph a demand curve and pork price-quantity combinations corresponding to the two analyzed years (current year and next year). Describe the results of your analysis.

11. Explain the reasons that buyers of broiler chickens and pork filed antitrust lawsuits against the largest broiler and pork processors in the United States. Discuss the role of Section 1 of the Sherman Act in regulating the conduct of broiler and pork processors in the analyzed industry situation. Explain the recent outcomes of the antitrust lawsuits filed by the buyers of broiler chickens and pork against the largest processors.

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Appendix I. U.S. Broiler and Pork Industries: Nominal and Real Price Analysis

Nominal wholesale prices are used in the empirical analysis presented in the case study for the following reasons.

(1). Figure 4 demonstrates changes in output quantity and output price due to the exercise of seller market power of meat processors. To understand the effect of a reduction in the output quantity on the output price—the output price increase or the overcharge—the output price has to be assumed to be an actual market price (nominal price). If a real price (the price adjusted for inflation) is used, theoretically there may be a price decrease or no price increase depending on the adjustments made to the price series. Figure 4 explains the industry's conduct and performance in the short-run period. For the empirical analysis to be consistent with this figure, nominal wholesale prices are used.

(2). When meat processing companies make decisions on output quantities to produce, they consider actual market prices that they currently observe. For example, when broiler and pork processors made public statements on their plans to implement production cuts, they made these production decisions based on current market prices (see several excerpts from the complaints presenting these statements included in Section 3 of the case study). Similarly, agricultural producers in general make their production decisions by taking into consideration current market prices (see a discussion of a general agricultural production and price cycle and a discussion of a hog supply and price cycle included in Section 3 of the case study).

(3). The empirical analysis presented in this case study is a very simplified version of the analysis that would be used in antitrust proceedings to calculate damages: the overcharge rectangle in Figure 4. When the overcharge (the output price increase due to illegal collusion) is calculated, actual firm-specific transaction prices are used. These prices are not adjusted for inflation, because this adjustment may distort the size of damages and may lead to lower damages or no damages.

(4). Some of the U.S. Department of Agriculture Economic Research Service reports, which compare yearly production and price data for agricultural commodities over several years use actual market prices (Dohlman and Livezey 2005; Dohlman, Foreman, and Da Pra 2009).

Table A1 presents descriptive statistics for nominal and real wholesale prices of broiler chickens like the one reported in Table 7. To adjust nominal prices for inflation two indices are used. The first one is the Producer Price Index (PPI) reported by the U.S. Bureau of Labor Statistics (BLS) for the aggregate group "meats, poultry, and fish" (U.S. Bureau of Labor Statistics 2022a). The second one is the Wholesale Price Index (WPI) for broilers reported by the U.S. Department of Agriculture Economic Research Service (2022b).[24] The changes in the monthly average real prices between the pre-PC and PC periods depend on the index used to adjust nominal prices.

The monthly average real wholesale price calculated using PPI decreases from 48.13 cents per pound in the pre-PC period to 45.49 cents per pound in the PC period, which is a decrease by 2.64 cents per pound or 5.5 percent. The monthly average real price calculated using WPI increases from 56.57 cents per pound in the pre-PC period to 57.11 cents per pound in the PC period, which is an increase by 0.53 cents per pound or 0.9 percent. This price increase is much smaller in magnitude than the monthly

[24] While the BLS PPIs for "poultry" and "chicken" groups are available, their values are missing for all months of 2009, therefore they are not used in the analysis.

average nominal price increase: 14.43 cents per pound or 22.5 percent. The teaching note Excel file includes data and calculations.

Table A1. The U.S. Broiler Chicken Monthly Wholesale Nominal and Real Prices, 2000—2015

Average/Coefficient of Variation (CV)	Nominal Wholesale Broiler Price	Producer Price Index (PPI) for Meats	Wholesale Price Index (WPI) for Broilers	Real Wholesale Broiler Price Adjusted Using	
				PPI Meats	WPI Broilers
	Cents per pound	1982 = 100	1998–2000 = 100	Cents per pound	
Pre-Production Control Period (Pre-PC Period): 2000–2007					
Average	64.26	133.24	113.47	48.13	56.57
CV	0.16	0.08	0.15	0.12	0.03
Production Control Period (PC Period): 2008–2015					
Average	78.69	174.21	137.77	45.49	57.11
CV	0.11	0.12	0.11	0.10	0.01
Change: PC Period, Relative to Pre-PC Period					
Average	14.43	40.97	24.30	-2.64	0.53
Average (percentage change)	22.5	30.7	21.4	-5.5	0.9
CV	-0.05	0.04	-0.04	-0.01	-0.03
CV (percentage change)	-32.3	56.1	-29.0	-12.3	-76.1

Data source for nominal prices: USDA Economic Research Service (2022b).
Note: "PPI meats" is Producer Price Index (by commodity) for processed foods and feeds: meats, poultry, and fish; monthly, seasonally adjusted; Series ID WPS022 (U.S. Bureau of Labor Statistics 2022a). "WPI broilers" is composite wholesale price index for broilers; monthly (U.S. Department of Agriculture Economic Research Service 2022b). Real price = (Nominal price/Index) * 100.

Table A2 presents descriptive statistics for nominal and real wholesale prices of pork like the one reported in Table 7. To adjust nominal prices for inflation two indices are used. The first one is the Producer Price Index (PPI) reported by the BLS for the aggregate group "meats, poultry, and fish" (U.S. Bureau of Labor Statistics 2022a). The second one is the PPI reported by the BLS for a less aggregated group "pork products" (U.S. Bureau of Labor Statistics 2022b). The changes in the monthly average real prices between the pre-PC and PC periods depend on the index used to adjust nominal prices.

The monthly average real wholesale price calculated using PPI for meats decreases from 48.60 cents per pound in the pre-PC period to 47.12 cents per pound in the PC period, which is a decrease by 1.48 cents per pound or 3 percent. The monthly average real price calculated using PPI for pork increases from 52.96 cents per pound in the pre-PC period to 55.80 cents per pound in the PC period, which is an increase by 2.84 cents per pound or 5.4 percent. This price increase is much smaller in magnitude than the monthly average nominal price increase: 18.86 cents per pound or 28.7 percent. The teaching note Excel file includes data and calculations.

Table A2. The U.S. Pork Monthly Wholesale Nominal and Real Prices, 2000—2017

Average/Coefficient of Variation (CV)	Nominal Wholesale Pork Price	PPI for Meats	PPI for Pork	Real Wholesale Pork Price Adjusted Using	
				PPI Meats	PPI Pork
	Cents per pound	1982 = 100		Cents per pound	
Pre-Production Control Period (Pre-PC Period) : 2000–2008					
Average	65.67	135.24	123.85	48.60	52.96
CV	0.13	0.08	0.08	0.11	0.09
Production Control Period (PC Period): 2009–2017					
Average	84.53	179.15	150.86	47.12	55.80
CV	0.18	0.10	0.13	0.14	0.09
Change: PC Period, Relative to Pre-PC Period					
Average	18.86	43.91	27.01	-1.48	2.84
Average (percentage change)	28.7	32.5	21.8	-3.0	5.4
CV	0.05	0.02	0.05	0.03	0.00
CV (percentage change)	40.2	21.8	60.7	32.2	-1.2

Data source for nominal prices: USDA Economic Research Service (2022b).
Note: "PPI meats" is PPI (by commodity) for processed foods and feeds: meats, poultry, and fish; monthly, seasonally adjusted; Series ID WPS022 (U.S. Bureau of Labor Statistics 2022a). "PPI pork" is PPI (by commodity) for processed foods and feeds: pork products, fresh, frozen, or processed, except sausage; monthly, seasonally adjusted; Series ID WPS022104 (U.S. Bureau of Labor Statistics 2022b). Real price = (Nominal price/Index)*100.

Appendix II. Price Flexibilities

Price flexibilities are elasticities associated with price-dependent (inverse) demand functions, according to which changes in product quantities affect changes in product prices (Hudson 2007). The price flexibility is the inverse of the own-price elasticity of demand associated with a quantity-dependent demand function (Houck 1965). Price-dependent demand functions generally reflect the nature of agricultural production and price cycles, according to which the total quantity of agricultural products produced during production seasons affects market prices for these products during marketing seasons (Moore 1919; Houck 1965; Bolotova 2017, 2019).

Price flexibility indicates a percentage increase (decrease) in product price, which follows a 1-percent decrease (increase) in product quantity demanded. Theoretically, price flexibilities are expected to be negative. There are two approaches to calculate price flexibilities.

The first approach is to use formula [1]. This approach is used when a price-dependent demand function (equation) is not available, but product prices and quantities for two consecutive years are available (Q1 and P1 are the price-quantity combination for the first year, and Q2 and P2 are the price-quantity combination for the following year). This approach is used in this case study.

$$Price\ Flexibility = \frac{\%\ \Delta\ in\ P}{\%\ \Delta\ in\ Q}, \quad (1)$$

where $\%\ \Delta\ in\ P = [\Delta\ in\ P/P1] \times 100\% = [(P2 - P1)/P1] \times 100\%$, $\%\ \Delta\ in\ Q = [\Delta\ in\ Q/Q1] \times 100\% = [(Q2 - Q1)/Q1] \times 100\%$, and Δ indicates "change."

The second approach is to use formula [2]. This approach is suitable when a price-dependent demand function (equation) is available. Price-dependent demand function: $P = a - b \times Q$,
where P is product price measured in $ per unit, and Q is product quantity measured in physical units.

$$Price\ Flexibility = -b \times \frac{Q}{P}, \quad (2)$$

where -b is the derivative of price with respect to quantity. Q and P in the above formula are associated with a particular point of interest or the average values. Note that formula [2] is a rearranged version of formula [1].

$$Price\ Flexibility = \frac{\%\ \Delta\ in\ P}{\%\ \Delta\ in\ Q} = \frac{\Delta\ in\ P}{P1} \times 100\% \Big/ \frac{\Delta\ in\ Q}{Q1} \times 100\% = \frac{\Delta\ in\ P}{\Delta\ in\ Q} \times \frac{Q1}{P1} = -b \times \frac{Q1}{P1}$$

Appendix III. A Methodology of Output Price Forecast Using Price Flexibility

Table A3. Output Price Forecast: Data and Formulas

Step		Notation	Value or Formula
	Current Year		
	Quantity (million pounds)	*Q1*	Value is provided
	Price ($ per pound)	*P1*	Value is provided
	% change in Quantity	*% change in Q*	Value is provided
	Price flexibility		Value is provided
	Next Year		***Calculate Using Formulas***
1	Change in Quantity (million pounds)	*change in Q*	$= \frac{Q1 * \%\ change\ in\ Q}{100}$
2	Quantity (million pounds)	*Q2*	$= Q1 + change\ in\ Q$
3	% change in Price	*% change in P*	$= Price\ Flexibility * \%\ change\ in\ Q$
4	Change in Price ($ per pound)	*change in P*	$= \frac{P1 * \%\ change\ in\ P}{100}$
5	Price ($ per pound)	*P2*	$= P1 + change\ in\ P$

Note: The objective of a price forecast is to predict the product price in the next year (P2). The teaching note Excel file provides all formulas and answers to Questions 9 and 10.

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