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ARTICLE

Horizontal merger simulation in a Cournot oligopoly with competitive fringe: The U.S. broiler industry case

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Abstract
This article analyzes the impact of a recent merger between the third and the seventh largest broiler producers in the United States on the equilibrium of the downstream broiler market. Reflective of the broiler industry market structure, in the theoretical part of the article we adopt the model of a Cournot oligopoly with a competitive fringe and then apply merger simulation to predict the welfare effects. We fit our theoretical framework to the pre-merger data under the assumption of different numbers of oligopoly firms. The results suggest that the merger between Sanderson Farms and Wayne Farms will significantly increase the market price of chicken meat and decrease consumer surplus, and that the magnitude of these impacts hinges on the size of the oligopoly. The net welfare effect could be positive or negative, but it is not statistically significant at the 5% level.

KEYWORDS
competitive fringe, cost synergies, horizontal merger, merger simulation

JEL CLASSIFICATION
L13, D22, Q10

1 | INTRODUCTION

Antitrust laws play an important role in the United Sates and other countries, as they try to protect consumers from being deprived of the benefits of competition. Section 2 of the Sherman Act (1890) makes it illegal to monopolize or attempt to monopolize a market and prohibits conspiracies that result in monopolization. Another important piece of federal legislation is the Clayton Act (1914), which prohibits mergers and acquisitions if they "substantially lessen competition" or "tend to create a monopoly." The antitrust laws are enforced in three ways: through the Antitrust Division of the Department of Justice (DOJ), through the administrative procedure of the Federal Trade Commission (FTC), and through private proceedings (Pindyck & Rubinfeld, 2013). When firms want to pursue a substantial merger, they must report it to the DOJ and the FTC, which are responsible for evaluating the likely effect of the merger and deciding whether to approve it.

In this article, we focus on a recent merger between two large poultry (broiler) companies: Sanderson Farms and Wayne Farms. On August 9, 2021, Cargill, Continental Grain Company (two giants in the food and farming industry), and Sanderson Farms (No. 3 broiler company) announced a joint venture between Cargill and Continental Grain Company that would acquire Sanderson Farms. As a result of this acquisition, Wayne Farms (No. 7 broiler company), a subsidiary of Continental Grain Company, would be merged with Sanderson Farms to form a new, privately held poultry company, named Wayne-Sanderson Farms. After the merger, Sanderson Farms would cease to exist as one of only three publicly traded broiler companies. After yearlong scrutiny by antitrust agencies, the $4.5 billion acquisition was approved in 2022. The approval raised some eyebrows about the potential effect of this merger on the competitiveness of the poultry industry, which, contemporaneously with this merger, has been plagued by an avalanche of collusion/price-fixing civil and criminal litigation cases (see Sheng & Vukina 2024).

To evaluate the welfare effects of this merger, we focus on the downstream broiler meat market and assume a Cournot oligopoly model with a competitive fringe to describe the broiler industry market structure. The Cournot model is a standard framework for analyzing market power issues in homogeneous goods industries, such as poultry, that have no well-established brand loyalties. The introduction of the competitive fringe of price-taking firms breaks the strict relationship between market shares and margins that characterize the standard Cournot model. The existence and the uniqueness of a Nash-Cournot equilibrium for a Cournot oligopoly with a competitive fringe have been established by Sherali et al. (1987). After empirical estimation of the demand and cost functions, we use merger simulation to predict how the merger between the two companies affects the market equilibrium.

An important characteristic of the poultry industry is that even though the biggest poultry companies have a much larger market share than others—each of the 10 largest poultry companies has a market share greater than 3%—the combined share of the remaining companies is not trivial either. Outside the top 10 broiler companies, the combined market share of other companies in 2021 was 21.19% (see Table 1). Fellner (1949) described this type of market structure as a "partial" oligopoly since the existence of a sizable competitive fringe has a significant influence on the equilibrium. Soyster and Sherali (1981) pointed to the copper industry as a good example of an oligopoly with a competitive fringe, where the leading 14 copper companies control 80% of the market, and the competitive fringe controls the remaining 20% market share. The broiler industry fits into this mold quite well.

The literature on the merger effects on the Cournot-Nash equilibrium is substantial. Salant et al. (1983) showed that in a static Cournot model, exogenous horizontal mergers are not beneficial for the merged firms unless their market share is greater than 80%. Farrell and Shapiro (1990) provided a comprehensive theoretical basis for the merger simulation with the Cournot model. They pointed out that under the framework of the standard Cournot model, a merger without cost synergies will cause the price to rise. They provided sufficient and necessary conditions under which profitable mergers will decrease price (i.e., the cost synergies dominate) and increase social welfare. Vergé (2010) extended Farrell and Shapiro (1990) by showing that as long as there are no synergies, consumers are unlikely to benefit from mergers, even in the existence of the appropriate structural remedies required by authorities. Some notable extensions of the standard Cournot model include Davidson and Mukherjee (2007), who considered a Cournot model with free entry and found that with only moderate cost synergies, mergers of a small number of firms could be beneficial to both the merged firms and society. Rouskas (2023) analyzed a dynamic Cournot model and showed that

TABLE 1 The 32 largest broiler companies in 2021.

Company	RTC	Live weight	Share	Number of plants
Tyson Foods	200.10	228.70	19.99%	120
Pilgrim's Pride Corp.	163.55	181.12	15.83%	82
Sanderson Farms, Inc.	94.55	101.90	8.91%	33
Perdue Farms, Inc.	62.30	75.07	6.56%	40
Koch Foods, Inc.	60.74	72.31	6.32%	24
Mountaire Farms, Inc.	65.56	72.08	6.30%	14
Wayne Farms, LLC	50.30	56.10	4.90%	26
Peco Foods	33.90	43.10	3.77%	17
George's Inc.	31.20	35.94	3.14%	19
House of Raeford Farms	29.20	35.20	3.08%	16
Foster Farms	23.00	33.11	2.89%	21
Amick Farms LLC	25.00	28.00	2.45%	9
Simmons Foods Inc.	22.10	26.20	2.29%	10
Case Foods Inc.	20.70	23.87	2.09%	12
Fieldale Farms	15.80	19.80	1.73%	8
Mar-Jac Poultry	15.88	19.12	1.67%	12
OK Foods Inc.	15.50	14.40	1.26%	8
Lincoln Premium Poultry	9.60	12.00	1.05%	3
Claxton Poultry Farms	8.73	10.69	0.93%	5
Farmer's Pride Inc.	5.40	7.80	0.68%	3
Allen Harim Foods	7.00	7.60	0.66%	6
Harrison Poultry Inc.	5.60	6.17	0.54%	3
Miller Poultry	3.47	4.46	0.39%	4
Golden-Rod Broilers Inc.	3.49	4.41	0.39%	5
Empire Kosher Poultry Inc.	1.85	3.70	0.32%	4
Holmes Foods	2.70	3.20	0.28%	5
Gerber's Poultry	2.00	2.80	0.24%	3
FreeBird Chicken	2.29	2.38	0.21%	1
Shenandoah Valley	1.60	2.00	0.17%	1
Murray's Chicken	0.83	1.30	0.11%	2
Jamaica Broilers	1.05	1.25	0.11%	6
Agri Star Meat & Poultry	0.27	1.03	0.09%	1
Total	985.26	1136.81	99.37%	523

Note: Ready-to-cook (RTC) and live-weight quantities are in millions of pounds per week. Plants include slaughter and further processing plants, hatcheries, and feed mills. The market share is based on live weight.

exogenous horizontal mergers with a small number of firms can be profitable even if the initial number of firms is quite large.

Empirical studies of merger simulations with a Cournot model or its variants in different industries are plentiful. Lundmark and Nilsson (2003) and Wårell and Lundmark (2008) analyzed the price and welfare effects of mergers in the iron ore industry. They assumed a standard Cournot model with a linear demand and quadratic cost. They calibrated the model by fitting it to the pre-merger market shares and the price elasticity of market demand obtained from previous studies.

They found that the welfare effect of these mergers was negative, which did not support the European Commission's decisions to approve them. Greenfield et al. (2015) utilized a Cournot model with a competitive fringe to predict the price effect of Tesoro's 2013 acquisition of British Petroleum's refinery in Los Angeles. They also assumed a linear demand and a quadratic cost function, and they used calibration to obtain the required parameters. Brown and Eckert (2018) developed a Cournot model of Alberta's wholesale electricity market incorporating firms' forward positions. When applying merger simulation, they used a combination of calibration and estimation to approximate the demand and cost functions.

Using two public data sources—the U.S. Department of Agriculture's weekly and monthly reports on poultry markets and the WATT Poultry USA broiler industry annual surveys—our simulation results suggest that the merger between Sanderson Farms (No. 3) and Wayne Farms (No. 7) will benefit suppliers at the cost of consumers, and the magnitude of the impact is sensitive to the size of the oligopoly. However, the net welfare effect is not significant at the 5% level. Finally, based on Nocke and Whinston (2022), we propose a concentration-based threshold applicable to the model of a Cournot oligopoly with a competitive fringe, which can determine whether a merger will harm consumers solely relying on pre-merger information. The insight from the concentration-based threshold is consistent with our merger simulation results.

Most existing literature in the field deals with mergers in industries characterized by differentiated products where price competition, that is, Bertrand-type oligopoly models, is better suited for modeling the industry structure and conduct. Only a few studies (e.g., Brown & Eckert, 2018; Greenfield et al., 2015; Lundmark & Nilsson, 2003) apply merger simulation techniques to study horizontal mergers in homogeneous product markets. None of them, however, study mergers in the broiler industry, even though there have been a substantial number of those over the years. In addition to being the first study that applies merger simulation techniques to the broiler industry, our work contributes to the literature in three important ways. First, we model the industry as a Cournot game with a competitive fringe. Considering that only 32 broiler companies control almost the entire market and the top seven companies control 69%, with each one of them directing more than 5% market share, it would be difficult to argue that the industry is perfectly competitive. However, from a game-theoretic point of view, claiming that all 32 firms are strategic competitors also does not make too much sense; hence, a natural choice becomes a Cournot with competitive fringe model. The problem with implementing such a model in merger simulations is that the cutoff between strategic and competitive firms is not directly observable. Our second contribution is an empirical test designed to select the preferred model among candidate models, providing a robust framework for dealing with this issue. Our final contribution is the modification of the Nocke-Whinston concentration-based threshold criterion for horizontal mergers in the pure Cournot model into one that fits the Cournot with competitive fringe model. Considering these contributions, we believe that our study blends methodological innovation and empirical relevance, contributing to broader literature beyond its specific focus on the broiler industry.

2 | BACKGROUND

The U.S. broiler industry is a prime example of industrialized agriculture. The industry has developed as a vertically integrated chain relying on contract production with independent farmers as a dominant mode of organization. Broiler companies, sometimes referred to as integrators, control all stages of live production (breeder hens, hatching eggs, broilers), as well as processing and marketing, except for genetics (primary breeding). Contracting and vertical integration gave the industry greater control of product volume and quality, which proved to be critical for meeting the needs of large food service companies and supermarket retail chains.

From an upstream perspective, the broiler industry is regionally segmented due to the logistical constraints of growing live birds. Live birds are highly sensitive to transportation, with long-distance travel leading to increased mortality and weight loss. As a result, firms can exert significant market power over contract growers in localized markets, as these growers are geographically bound to the firm's nearby processing plants. Analyzing the consequences of this horizontal merger on the upstream market for contract grower services is another project that would require data on exact locations of contract farms and processing plants. Drawing circles around processing plants would define feasible contracting regions. To the extent that the intersection of two merged companies' feasible circles contains both companies' growers, the proposed merger would eliminate competition in that region because instead of two, the growers would now have only one company to contract with. On the other hand, the downstream market for broiler meat operates on the national and even international scale. Unlike live birds, packaged broiler meat can be transported over large distances without significant degradation in quality or weight. For this reason, poultry companies centralize their sales and marketing strategies at the corporate level, ensuring efficient coordination of product distribution across a wide geographic area.

While the presence of significant economies of scale in processing favored large companies, the substantially smaller economies of scale in live production had the opposite effect such that, overall, the industry is not highly concentrated. Of course, some companies are larger than others, but still many firms actively compete in the broiler market and no single firm dominates. As seen in Table 1, the total market share based on the live weight of the 32 largest broiler companies in 2021 was 99.37%, and the largest company, Tyson, controlled less than 20% of the market. Given that only 32 broiler companies control the entire market, with the top seven firms holding 69% of the market share (each with more than 5%), it is clear that the industry is far from perfectly competitive. However, from a game-theoretic perspective, treating all 32 firms as strategic competitors also seems unrealistic. Therefore, a more appropriate framework for this market is a Cournot model with a competitive fringe, where the largest firms engage in strategic behavior while smaller firms act as price takers.

The landscape of the broiler industry was, for quite some time, described by a few large publicly traded companies and a group of sizable private firms (Sheng & Vukina, 2024). Between 2000 and 2020, the broiler industry concentration gradually increased. The aggregate market share of the top four broiler companies (CR4 ratio) increased from 43% to 52%, with a peak of 59% in 2006. For comparison purposes, the Herfindahl–Hirschman Index (HHI) computed based on the 50 largest broiler companies and older data was 1195 in 2013, slightly up from 1103 in 1997, with a peak value of 1442 in 2006. During the first decade of the century, the broiler sector was characterized by a significant number of bankruptcies and intense merger and acquisition activity. The meltdown of the financial sector, coupled with high corn prices, were the main culprits. For the most part, larger firms acquired smaller counterparts, except for Gold Kist, which was No. 3 when it was acquired by Pilgrim's Pride, which was then No. 2. The Pilgrim's Pride case is interesting: after a series of aggressive acquisitions (Wampler Foods Inc. in 2001, ConAgra Poultry Co. in 2003, and Gold Kist in 2006), Pilgrim's Pride filed for Chapter 11 bankruptcy protection on December 1, 2008, but successfully emerged from it a year later after 64% of its stake was acquired by the Brazilian meat conglomerate JBS S.A. (for details, see Vukina and Zheng, 2015).

Even after this wave of mergers and acquisitions, the broiler industry remained less concentrated than the rest of the U.S. meat complex. The comparison with beef and pork industries based on the last available data for 2007 illustrates this point. The CR4 of beef packers was 83.5% and 66% for pork packers, compared to 59.5% for broiler producers (Hendrickson & Heffernan, 2007).

During the decade prior to the merger of Sanderson and Wayne, the industry concentration actually decreased. Based on companies' shares in 2021 (see Table 1), the pre-merger HHI stood at 945.14, the post-merger HHI was 1032.50, and the change in HHI was 87.36.[1] The CR4 in 2021 was 51.03%, also much lower than at its peak in 2006. These indices need to be put in context with *Horizontal Merger Guidelines* issued by the DOJ and the FTC.

[1]Because the HHI is computed as the sum of the squared percent shares of each firm, not having all firms in the industry is a problem. The above HHI is computed by ignoring the remainder of the 0.63% market share of very small companies. Alternatively, if we assume that the residual market share of 0.63% belongs to another fictitious firm, then the pre-merger HHI is 945.77, the post-merger HHI is 1033.13, and the change in HHI is 87.36—a negligible difference compared to the previous assumption.

In its earliest version, the 1968 *Guidelines* was built on a presumption that horizontal mergers that increase market concentration are inherently likely to lessen competition and reduce welfare (Shapiro, 2010). The approach to horizontal mergers was focused entirely on preventing industry concentration, and the thresholds were significantly more stringent than today. Interestingly enough, because the CR4 in 2021 was 51.03% (less than the threshold of 75%), less stringent anticompetitive presumptions applied, but given the acquiring firm's (Sanderson) share was 8.91% and the acquired firm's (Wayne) share was 4.9%, at that point in time, the merger might have been blocked (see Nocke & Whinston, 2022, fig. 1).

Following this tradition, the 1982 *Guidelines* introduced the HHI as a measure of market concentration and set enforcement thresholds based on the absolute value of post-merger HHI and the change in HHI following the merger (Shapiro, 2010). A rule of thumb is that the greater the post-merger HHI and the larger the change in HHI, the more likely it is that a merger will be challenged. If the post-merger HHI is less than 1500 or the change in HHI is less than 100, a merger will fall into the safe zone, which means that it is unlikely to be challenged. If the post-merger HHI is between 1500 and 2500 or the change in HHI is between 100 and 200, a merger is "likely" to be challenged. Finally, for a merger with HHI larger than 2500 and change in HHI larger than 200, it is "more likely than not" that a merger will be challenged.[2] Hence, based on the 1982 *Guidelines*, the Sanderson-Wayne merger clearly falls into the safe zone, indicating it was unlikely to be challenged.

Even though the 2010 *Guidelines* started to place less weight on market concentration–based evidence, the concept still plays a vital role in merger analysis. The theoretical basis for utilizing market concentration–based evidence has been widely discussed in the literature. Farrell and Shapiro (1990) pointed out there is no simple and unambiguous relationship between changes in HHI and changes in economic welfare. Specifically, with significant cost synergies, a merger that increases HHI can also increase welfare by replacing the less efficient way of production with a more efficient one. On the other hand, Nocke and Whinston (2022) argued that relying solely on the change in market concentration to analyze the unilateral price effect is theoretically and empirical meaningful for certain types of market structures (e.g., standard Cournot model with a constant marginal cost), and it is especially useful during the initial screening stage when there is not much information regarding margins and cost synergies.

Despite the low pre-merger HHI and the low post-merger increment in the HHI, the approval of this merger is still somewhat puzzling. In July 2022, the DOJ filed a civil complaint against Cargill, Sanderson Farms, and Wayne Farms, claiming that the processors "artificially suppressed compensation" and "deprived a generation of poultry-processing-plant workers of fair pay set in a free and competitive labor market" (Brown, 2023).[3] On the same day that the DOJ filed its civil lawsuit, it also filed a proposed final judgment in which the companies agreed to pay $85 million in restitution to their workers. The consent decree stipulated that, among other things, the defendants must cooperate with any further investigation or litigation related to information-sharing agreements regarding workers' pay. In statements, Cargill and Wayne-Sanderson Farms each said they disputed the DOJ's allegations and had admitted no wrongdoing. The same week, a $4.5 billion merger was completed. The restitution payments were equivalent to 1.9% of the merger deal. The new entity now controls roughly 14% of the poultry industry.

3 | MODELING APPROACH

3.1 | Theoretical model

Consider a two-stage game with an oligopoly consisting of N^r strategic firms and a competitive fringe consisting of N^c price takers, where all firms produce a homogeneous product with an inverse

[2] A figure illustrating the rules mentioned above can be found in Appendix A in the online supplementary appendix.
[3] The complaint also referenced 18 unnamed poultry-processor co-conspirators.

demand curve $P(Q)$. The oligopoly decides its output first by considering the response of the competitive fringe. After observing the oligopoly's choice, price-taking firms choose the output that equalizes marginal cost and market price. We also assume that (i) $P'(Q) < 0$; (ii) $P'(Q) + QP''(Q) < 0$; and (iii) all firms have a linear marginal cost function.

We define $Q = Q^c + Q^r$, where $Q^c = \sum_{l=1}^{N^c} q_l$ is the output supplied by all price-taking firms and $Q^r = \sum_{j=1}^{N^r} q_j$ is the output supplied by all strategic firms. The model can be solved by backward induction. Starting with the second stage, the profit-maximization condition for a price-taking firm, indexed by l, can be written as

$$P\left(Q^r + q_l + \sum_{i \neq l} q_i\right) = MC(q_l), \tag{1}$$

where $l \in \{1, 2, \ldots, N^c\}$. By solving the first-order condition, the optimal choice q_l^* can be written as $q_l^* = q_l^*(Q^r)$, and the optimal output of the competitive fringe is $Q^{c*} = \sum_{l=1}^{N^c} q_l^*(Q^r) = Q^{c*}(Q^r)$.

Then, in the first stage, strategic firms, indexed by j, expect that $Q^{c*} = Q^{c*}(Q^r)$ and choose quantity q_j to maximize its own profit function:

$$\pi_j = P\left(Q^{c*} + q_j + \sum_{i \neq j} q_i\right) q_j - C_j\left(q_j\right), \tag{2}$$

where $j \in \{1, 2, \ldots, N^r\}$. The corresponding first-order condition is

$$\frac{\partial \pi_j}{\partial q_j} = P + \frac{\partial P}{\partial q_j} q_j - MC_j\left(q_j\right) = 0, \tag{3}$$

where $\frac{\partial P}{\partial q_j}$ is the marginal effect of firm j's output on market price. Because $\frac{\partial P}{\partial q_j}$ in Equation (3) is not observable, it needs to be manipulated to obtain the following result:

$$\begin{aligned} \frac{\partial P}{\partial q_j} &= \frac{\partial P}{\partial Q^r} \frac{\partial Q^r}{\partial q_j} \\ &= \frac{\partial P}{\partial Q^r} \frac{\partial\left(\sum_{j=1}^{N^r} q_j\right)}{q_j} \\ &= \frac{\partial P}{\partial Q^r}. \end{aligned} \tag{4}$$

Equation (4) implies that the marginal effect of each strategic firm's supply on the market price is exactly the same, and equal to the marginal effect of all the strategic firms' supply on the market price.

Substituting Equation (4) into Equation (3) obtains

$$\begin{aligned} \frac{\partial \pi_j}{\partial q_j} &= P + \frac{\partial P}{\partial Q^r} q_j - MC_j\left(q_j\right) \\ &= P + \frac{\partial P}{\partial Q^r} \frac{Q^r}{P} \frac{P}{Q^r} q_j - MC_j\left(q_j\right) \\ &= 0. \end{aligned} \tag{5}$$

Q^r represents the derived or residual demand function faced by the oligopolists, obtained after subtracting the quantity supplied by the competitive fringe from the total demand. If we define $\epsilon^r = \frac{\partial Q^r}{\partial P}\frac{P}{Q^r}$ as the price elasticity of residual demand, and $s_j^r = \frac{q_j}{Q^r}$ as the market share of strategic firm j in the total market share of all strategic firms, the first-order condition (5) can be rewritten as

$$\frac{P - MC_j\left(q_j\right)}{P} = -\frac{s_j^r}{\epsilon^r}. \tag{6}$$

Equation (6), known as the Lerner index, implies that strategic companies with larger market shares have lower marginal costs. With the knowledge of the market demand function, solving the system of N^c equations in (1) and N^r equations in (3), one obtains the equilibrium price and quantities. Our initially stated assumptions (i), (ii), and (iii) are sufficient to guarantee the existence of a unique Cournot-Nash with competitive fringe equilibrium.[4]

The presence of a competitive fringe changes the nature of the market equilibrium. A simple way to illustrate the point is to consider a case of N^r symmetric oligopolists with a competitive fringe. The marginal cost function for each oligopolist is q_j/K^o, and the aggregate marginal cost function for competitive fringe is Q^c/K^c, where K^o and K^c are parameters measuring firms' capital stock. Assume a linear inverse demand function $P = a - bQ$, $(a, b > 0)$. The equilibrium price in the standard Cournot model is $P_1 = \frac{abK^o + a}{(1+N^r)bK^o + 1}$. With the presence of a competitive fringe, the corresponding residual demand function faced by oligopolists is $P = A - BQ^m$, where $A = \frac{a}{1+bK^c}$ and $B = \frac{b}{1+bK^c}$. Since $A < a$, $B < b$, and $\frac{A}{B} = \frac{a}{b}$, the residual demand curve is lower and flatter than the total demand curve, but they have the same intercept on the quantity axis. In other words, the residual demand curve is more elastic than the total demand curve. Because the equilibrium price in the case of N^r symmetric oligopolists with a competitive fringe equals $P_2 = \frac{ABK^o + A}{(1+N^r)BK^o + 1}$, it is easy to show that $P_1 > P_2$, and the existence of a competitive fringe reduces the market power of the oligopolists and leads to a lower equilibrium price. The intuition behind this result is that whenever the oligopolists want to set a higher price by producing less, the competitive fringe is always willing to supply some extra quantity at that price, which ultimately leads to a lower price overall.

3.2 | Empirical model

Conducting merger simulation requires knowledge of the market demand function and marginal costs of each firm (Davis & Garcés, 2009). We consider the following linear inverse demand function for broiler meat:

$$P_t = b_0 + b_1 Q_t + b_2 Pork_t + \boldsymbol{b_3 D_m} + b_4 t + b_5 t^2 + e_{dt}, \tag{7}$$

where P_t and Q_t are the price and quantity for broiler meat, $Pork_t$ is the price for pork, one of the main substitutes for chicken, $\boldsymbol{D_m}$ is a vector of monthly dummy variables, and t and t^2 capture the quadratic time trend. Following Schroeter (1988) and Zheng and Vukina (2009), we assume that e_{dt} has a mean of zero, and it follows an AR (1) process.[5] For the linear inverse demand function, $\epsilon = \frac{1}{b_1}\frac{P}{Q}$ is an estimator of the price elasticity of demand for broiler meat.

[4]The proof is based on Sherali et al. (1987), who showed that if the residual demand function faced by the oligopolists satisfies (iv) $P'(Q^r) < 0$, (v) $Q^r P(Q^r)$ is concave in Q^r, and (vi) the oligopolists's cost functions are convex and continuously differentiable, then there exists a unique Nash equilibrium for the Cournot model with a competitive fringe. Since a linear marginal cost function (iii) automatically satisfies the convexity (vi), it remains to be proven that (iv) and (v) are also satisfied given (i), (ii), and (iii). The formal proof of this result involves a rather long and tedious yet straightforward algebra, and it is available from the authors upon request.

[5]We also estimated the demand function by assuming an AR (2), AR (3), or AR (4) error term, and the results are basically the same.

Next, we need to retrieve information about the supply side by assuming a specific cost structure for each firm. Following Lundmark and Nilsson (2003) and Gandhi et al. (2008), we propose to model the marginal cost as a linear function of quantity:

$$MC_i = \frac{q_i}{k_i} + c_i, \tag{8}$$

where c_i is the lower bound of the marginal cost and k_i is a measure of each firm's capital stock.[6] In the context of the broiler industry, it is easy to think about k_i as the number of processing plants operated by each firm. When firm i is merged with firm j, the new firm will own all the plants originally owned by the merging firms. Hence, the marginal cost function for the new firm (denoted by m) can be written as

$$MC_m = \frac{q_m}{k_i + k_j} + \min\{c_i, c_j\}. \tag{9}$$

The cost synergies from the merger arise from the possibility that the merged firm could produce the same output at a lower cost than any of the merging firms. The source of cost synergies could be the reduction in transportation cost caused by proximity to more markets for finished products or the reduction in overhead cost obtained by merging certain functions of individual production divisions. Another source of cost synergies is shifting products from less efficient plants to more efficient ones (perhaps with the closure of some inefficient plants).

Substituting Equation (8) into Equation (1) and summing over l, we obtain

$$Q^c = \left(\sum_{l=1}^{N^c} k_l\right) P = K^c P + C, \tag{10}$$

where $K^c = \sum_{l=1}^{N^c} k_l$ and $C = -\sum_{i=1}^{N^c} k_i c_i$. The supply function for the competitive fringe (10) implies that the price elasticity of supply of the competitive fringe (denoted as η^c) should be equal to 1.

We can estimate K^c and C by proposing the following empirical model:

$$Q_t^c = K^c P_t + C + e_{st}, \tag{11}$$

where we assume that $E(e_{st}) = 0$, and it follows an AR (1) process. Since $C = -\sum_{i=1}^{N^c} k_i c_i$ and c_i is non-negative by nature, C should be non-positive. Hence, we impose the restriction $C \leq 0$ when estimating (11).

Finally, we need to estimate the first-order conditions for each strategic firm. Substituting Equation (8) into (6), we obtain

$$\frac{P - MC_j}{P} = 1 - \frac{q_j}{Pk_j} - \frac{c_j}{P} = -\frac{s_j^r}{\epsilon^r}. \tag{12}$$

It can be shown that ϵ^r satisfies the following theoretical relationship:

$$\epsilon^r S^r + \eta^c S^c = \epsilon, \tag{13}$$

[6]Another popular assumption is a constant marginal cost function up to a certain production capacity.

where S^r and S^c are the shares of all strategic firms and all price-taking firms in the industry total output and all elasticities are previously defined.[7]

Substituting Equation (13) into (12) yields

$$\begin{aligned} 1-\frac{q_j}{Pk_j}-\frac{c_j}{P} &= -\frac{s_j}{S^r\epsilon^r} \\ &= -\frac{s_j}{\epsilon - S^c\eta^c}, \\ &= -\frac{q_j}{\epsilon Q - Q^c\eta^c} \end{aligned} \tag{14}$$

which after some algebra gives the expression for the optimal output of the strategic firm j:

$$q_j = k_j\left[\left(1+\frac{q_j}{\epsilon Q - Q^c\eta^c}\right)P\right] - c_jk_j. \tag{15}$$

As ϵ can be estimated from the demand function and $\eta^c = 1$, the right-hand side of Equation (15) is linear in k_j. Hence, we can estimate k_j by proposing the following empirical model:

$$q_{jt} = k_jZ_{jt} + F_j + e_{jt}, \tag{16}$$

where $Z_{jt} = \left(1+\frac{q_{jt}}{\epsilon Q_t - Q_t^c}\right)P_t$ and $F_j = -c_jk_j \le 0$. We also assume that $E(e_{jt}) = 0$ and that it follows an AR (1) process. Since F_j is a non-positive constant term, we need to regress a constrained model when estimating (16).

4 | ESTIMATION RESULTS

In the empirical part of the article, we rely on the following data sources. Monthly national ready-to-cook (RTC) broiler quantity data from 2000 to 2021 are obtained from the United States Department of Agriculture (USDA) Poultry Slaughter Annual Summary, which contains state and U.S. totals of the number of heads and live weight of chickens, turkeys, ducks, and other poultry slaughtered under federal inspection. The data we use are the chilled and frozen pounds of certified young chickens slaughtered under federal inspection.[8] Weekly national RTC broiler wholesale prices are collected from Weekly Composite Weighted Average Prices for RTC Broiler/Fryers Reports (2000–2012) and Weekly National Whole Broiler/Fryer Reports (2013–2021). We transfer the weekly data to monthly data by calculating the monthly average price.

The annual firm-level quantity data from 2000 to 2021 are obtained from the WATT Poultry USA annual surveys of the top U.S. broiler companies. For the purpose of estimation, we need to transfer the annual data to monthly data. We assume that firm shares are stable during any given year and then compute the monthly firm-level RTC quantities by multiplying the monthly national RTC broiler quantities by the annual market share of each firm.[9]

[7]The interested reader can find the proof in Appendix B in the online supplementary appendix.

[8]In fact, for the data in 2000, we did not find the corresponding annual summary. Instead, we get the data from the USDA Poultry Slaughter Monthly Report.

[9]The WATT Poultry USA annual surveys contain quantity data for both total live weight and RTC weight. For consistency purposes, we should have used the RTC weight to calculate the market share for each firm. However, the sum of market share measured by RTC weight is greater than 1, which is caused by the conversion rate between live weight and RTC weight. In fact, in our other research in the poultry industry over the years, we have tried to resolve this issue with the publisher of the survey results, but we could not get a satisfactory answer. The discrepancies are so small that they cannot possibly produce any difference in the obtained results. Hence, we use total live weight to calculate the market share for each firm.

TABLE 2 Data summary statistics.

Variable	Definition	Mean	Std. dev.	Min	Max
P_t (cents per pound)	Broiler price	79.68	16.35	34.57	124.39
Q_t (million pounds)	Broiler quantity	3130.30	379.91	2322.17	4100.15
$Pork_t$ (cents per pound)	Pork price	138.61	27.21	91.18	241.36
$SoybeanMeal_t$ (dollars per short ton)	Soybean meal price	299.58	99.95	153.11	564.91
$Corn_t$ (cents per bushel)	Corn price	364.66	144.37	152	763
Number of observations	264				

Monthly pork wholesale prices from 2000 to 2021 come from the USDA Meat Price Spreads data set, and monthly corn prices during the same period come from the USDA Quick Stats database. We use the daily cash close price for the Chicago Board of Trade (CBOT) soybean meal futures contracts as the price for soybean meal and calculate its monthly average.[10] Table 2 presents summary statistics for all important variables.

In what follows, we present the estimation results for the inverse demand function (Equation 7), the supply function of the competitive fringe (Equation 11), and the first-order condition for each strategic firm (Equation 16). Following Zheng and Vukina (2009), we estimate each equation separately using a limited information method, which avoids the misspecification of one equation being propagated throughout the whole system.

As the quantity variable Q_t in Equation (7) is endogenous, we need to find proper instruments. In the demand function estimation, we use instruments that directly affect the supply side of the market but do not have any direct impact on demand. Typically, supply shifters like feed prices are good candidates.[11] Since chickens sold as "broiler-fryers" are about 7 weeks old when they are slaughtered, the feed price used as an instrument for Q_t is lagged 2 months ($Feed_{t-2}$).[12] Supply shifters influence the cost structure of producers, thereby affecting the quantity supplied and therefore prices in equilibrium. However, these variables do not have any direct impact on the preferences or purchasing behavior of consumers. Therefore, under the assumption that these supply shifters only affect the demand equation indirectly through their influence on equilibrium prices and quantities (the endogenous variables), the exclusion restriction is valid. The instruments are exogenous because they do not directly enter the demand function's error term, meaning they are uncorrelated with unobserved factors that affect demand.

Since the error term e_{dt} follows AR (1) and could be heteroskedastic, we choose a heteroskedastic and autocorrelation-consistent (HAC) standard error estimator. All the models (Equations 7, 11, and 16) are estimated by the two-step optimal generalized method of moments (GMM) method.[13] The inverse demand function is estimated with the entire data set spanning the period from 2000 to 2021. The estimation results are in Table 3.

The reliability of the results depends on the quality of the instruments, so we run both under-identification and weak-identification tests for the instrumental variables. The under-identification test is a Lagrange multiplier (LM) test of whether instruments are correlated with the endogenous variables. Under the null hypothesis, instruments are uncorrelated with the endogenous regressors, and the corresponding statistic is distributed as a chi-square with $(L_1 - K_1 + 1)$ degrees of freedom,

[10]The price data for soybean meal are available at Barchart.com.

[11]See chapter 16 of *Introductory econometrics* by Jeffrey M. Wooldridge (2007) for more details.

[12]We approximate the broiler feed price with the weighted average of 70% corn and 30% soybean meal price (see Landes et al. 2004).

[13]GMM is widely used for estimating parameters of statistical models in situations where the classical assumptions (like homoskedasticity or normality of errors) do not hold. The optimal two-step GMM is an extension of the basic GMM and is preferred due to its efficiency gains. In the first step, the model parameters are estimated with an initial weighting matrix (identity matrix). In the second step, these estimates are refined using an optimal matrix, typically the inverse of the first step's covariance matrix (see Zsohar 2012).

TABLE 3 Estimation results for the linear inverse demand function.

Variable	Coefficient	Standard error
Q_t	−0.053**	0.024
$Pork_t$	0.16***	0.044
t	0.52 ***	0.090
t^2	−0.00063***	0.00020
Constant	164.75***	62.69
Monthly dummies included but not reported	December dropped	
Kleibergen-Paap rk LM statistic	13.32	
Kleibergen-Paap rk Wald F statistic	22.26	

Note: *, **, and *** mean coefficients are significant at the 10%, 5%, and 1% significance level, respectively.

where L_1 is the number of instrumental variables and K_1 is the number of endogenous variables. The Kleibergen-Paap rk LM statistic is often used for under-identification tests, especially when the independent and identically distributed (i.i.d.) assumption for the error term is dropped. For the linear inverse demand function, the value of the Kleibergen-Paap rk LM statistic is much larger than the critical value at the 1% significance level, so we can reject the null hypothesis of under-identification at 1%. When instruments are correlated with endogenous variables, but only weakly, estimators can also perform poorly. The Kleibergen-Paap rk Wald F-statistic is used to test weak identification when the error term is not i.i.d. The instrument we choose also passes the weak-identification test.

Based on the Table 3 estimates, the price elasticity of demand for broilers, computed at the mean price and quantity for 2021, is −0.51, which indicates that the demand for broiler meat is not elastic. This result is consistent with most of the literature in the field and is directly supported by Chi and Lovett (2020). The estimated coefficient for pork price is significantly positive, and it suggests that pork and broiler meat are substitutes.[14]

Then we estimate the supply function of the competitive fringe (Equation 11). The supply of the competitive fringe Q^c is calculated by subtracting the supply of the oligopolists (the top N^r firms) from the total quantity Q. To avoid the possible influence of the alleged collusion of a group of larger broiler firms to restrict output and fix prices on the behavior of the competitive fringe (for details, see Sheng & Vukina, 2024), we only use data from August 2019 to December 2021 to estimate Equation 11. Since C is non-positive, we impose this constraint when estimating Equation (11). As the broiler price is endogenous in the supply function, pork price from the demand side is chosen as an instrument. It passes both the under-identification and weak-identification tests. The estimated value of C is exactly 0, which suggests that the values of c_i are all zeros. The estimated K^c is sensitive to the choice of N^r (see Table 4). The results show that estimated K^c is negatively correlated with N^r. Since we assume that K^c measures the number of plants owned by the competitive fringe, the negative relationship between N^r and K^c is obvious: if more firms are counted as strategic firms, fewer firms with their plants would belong to the competitive fringe.

Next, we need to estimate the first-order condition for profit maximization of each of the Cournot contestants, expressed as their supply functions. To estimate Equation (16), we use the data from 2010 to 2021 because the industry HHI is stable around the level 1000 during this time period and the capital stock of each firm remained substantially unchanged.[15] Since F_j is non-positive, we impose this constraint when estimating Equation (16). Even though the monthly firm-level quantity

[14]The estimates of the double-log functional form of the inverse demand function are very similar.

[15]Based on Watt Poultry USA survey data, during the 2010–2021 period, the number of slaughter plants for the top eight firms in the industry increased by only 6%, from 103 to 109.

TABLE 4 Estimates of the supply function of the competitive fringe.

N^r	K^c	Standard errors
4	20.64***	0.92
5	17.94***	0.80
6	15.33***	0.69
7	13.26***	0.60
8	11.60***	0.51
Kleibergen-Paap rk LM statistic	13.22	
Kleibergen-Paap rk Wald F statistic	647.30	

Note: *, **, and *** mean coefficients are significant at the 10%, 5%, and 1% significance level, respectively.

data from the WATT Poultry USA annual surveys have the panel structure, we estimate Equation (16) for each firm separately. Because in our structural model there are no common covariates or fixed/random effects across equations for different strategic firms, there is no advantage of using the panel structure. As variable Z_{jt} is endogenous, we use pork price as a valid instrument. The estimated value of F_j is exactly 0 for all strategic firms. Table 5 presents the estimated k_j for Cournot firms under different N^r. Notice that the estimated k_j gradually increases as N^r increases, but the ordering of k_j is always the same as the ordering of market shares. This result is consistent with the Lerner index in Equation (6), which implies that firms with larger market share should have lower marginal costs and hence larger capital stocks. The fact that k_j estimates are roughly proportional to the number of actually observed plants is a sign that k_j represents a good measure of capital stock.

The estimated pre-merger monthly price and quantity for the whole industry on a year-by-year basis can be obtained by solving the system of Equations (7), (11), and (16) after substituting estimated parameters. The critical question becomes what is the correct model to represent the broiler industry in terms of the oligopoly size, that is, the number of Cournot contestants. Under the assumption that $N^r < 7$, Wayne Farms belongs to the competitive fringe, and the merger happens between a strategic firm and a competitive firm. Under the assumption that $N^r \geq 7$, Wayne Farms is also part of the oligopoly, and the merger happens between two strategic players.

To address the issue, we do two things. First, we look at the goodness of fit of each model from $N^r = 4$ to $N^r = 8$ by computing the out-of-sample mean-squared prediction error, $MSE = \sum (y_i - \widehat{y}_i)^2$, where y_i is the observed price, industry output, top three firms' individual output, and other firms' total output, and $\widehat{y}_i$ is the prediction of these variables. Since the models are estimated by using data from 2000 to 2021, we calculate the out-of-sample MSE by using the data from the year 2022 (from January to August). The results show that MSE for $N^r = 4$ is 10043.61; MSE for $N^r = 5$ is 9131.54; MSE for $N^r = 6$ is 8297.97; MSE for $N^r = 7$ is 8172.79; and MSE for $N^r = 8$ is 8173.19. They indicate that the best model (with the smallest MSE) is $N^r = 7$, and the merger occurred between two strategic firms.

Second, by comparing these two adjacent cases, $N^r = 7$ to $N^r = 6$, we want to see whether the merger effect between two strategic firms is different from the merger effect between a strategic firm and a competitive firm. The comparison between the two scenarios for the 2022 pre-merger equilibrium is given in Table 6. We say that the prediction is statistically significant at the 5% level if the empirical data point lies inside the 95% confidence interval.[16] The results of the two models are qualitatively identical. They show that the total industry quantity as well as the two leading firms' (Tyson

[16]The 95% confidence intervals are obtained from 1000 bootstraps. Each time, a random sample is drawn from the original data set, all models are estimated, and the empirical distribution of the parameters of interest is recorded. Stata has a built-in command that can do nonparametric bootstrapping in a convenient way (see Mooney and Duval 1993).

TABLE 5 Estimates of the first-order conditions for Cournot oligopolists.

Firm	$N^r=4$	$N^r=5$	$N^r=6$	$N^r=7$	$N^r=8$	Number of plants
k^{Tyson}	9.57***	9.73***	9.90***	10.07***	10.22***	120
	(0.20)	(0.21)	(0.22)	(0.22)	(0.23)	
$k^{Pilgrim}$	7.33***	7.43***	7.52***	7.63***	7.71***	82
	(0.14)	(0.14)	(0.15)	(0.15)	(0.15)	
$k^{Sanderson}$	3.10***	3.11***	3.13***	3.15***	3.16***	33
	(0.10)	(0.10)	(0.10)	(0.10)	(0.10)	
k^{Perdue}	2.87***	2.88***	2.89***	2.91***	2.92***	40
	(0.05)	(0.05)	(0.05)	(0.06)	(0.06)	
k^{Koch}		2.40***	2.41***	2.42***	2.43***	24
		(0.05)	(0.05)	(0.05)	(0.05)	
$k^{Mountaire}$			2.05***	2.06***	2.07***	14
			(0.06)	(0.06)	(0.06)	
k^{Wayne}				1.91***	1.92***	26
				(0.04)	(0.04)	
k^{Peco}					1.39***	17
					(0.04)	

Note: Numbers in parentheses are the corresponding standard errors. *, **, and *** mean coefficients are significant at the 10%, 5%, and 1% significance level, respectively.

TABLE 6 Estimated pre-merger equilibrium in 2022.

	Empirical data	$N^r=6$	$N^r=7$
Average price	148.8	97.6	98.0
Total quantity	30,344.2	30,351.0**	30,281.0**
Q^{Tyson}	6096.9	5990.6**	6010.5**
$Q^{Pilgrim}$	4564.9	4810.3**	4833.9**
$Q^{Sanderson}$	2639.7	2237.9	2249.4
Q^{Perdue}	1838.9	2079.7	2092.3
Q^{Koch}	1979.9	1757.0	1764.7
$Q^{Mountaire}$	1905.9	1509.4	1518.0
Q^{Wayne}	1453.3	1618.2	1413.7**

Note: *, **, and *** mean coefficients are significant at the 10%, 5%, and 1% significance level, respectively.

and Pilgrim) quantities are significant at the 5% level in both models, whereas estimated price and other smaller firms' outputs are not (except for Wayne Farms when $N^r=7$).[17] The results are quite reasonable because our objective is not to directly forecast industry output, prices, and firm-level quantities. Instead, we estimate the demand and supply functions and then use these estimates to calculate equilibrium prices and quantities. Due to nonlinearities in the first-order condition, the estimation errors in the demand and supply functions are exaggerated when calculating the final results.

Finally, in Table 7, we present the estimated average marginal cost and the corresponding 95% confidence intervals for the top seven broiler companies in 2022 based on Equation (8).[18] As

[17]We need to point out that the average price in 2021 is about 100.78 cents per pound, but it increased by more than 50% in 2022. The broiler price surge in 2022 was caused by outbreaks of highly pathogenic avian influenza (HPAI; Zamani et al., 2024). Since the outbreaks of HPAI were unpredictable, the estimated price is closer to the average level in 2021.

[18]The marginal cost is calculated for each month; the average value is presented in Table 7.

TABLE 7 Estimated marginal cost in 2022.

Firm	$N^r = 6$	95% CI	$N^r = 7$	95% CI
Tyson	75.6**	[70.4, 85.4]	74.6**	[69.0, 85.0]
Pilgrim	80.0**	[75.6, 88.0]	79.2**	[74.6, 87.6]
Sanderson	89.4**	[86.4, 93.4]	89.3**	[86.4, 93.4]
Perdue	90.0**	[87.1, 93.9]	89.9**	[87.1, 93.7]
Koch	91.1**	[88.2, 94.7]	91.2**	[88.4, 94.8]
Mountaire	92.0**	[89.1, 95.4]	92.1**	[89.3, 94.5]
Wayne	97.6**	[94.0, 101.4]	92.5**	[89.7, 95.7]

Note: *, **, and *** mean coefficients are significant at the 10%, 5%, and 1% significance level, respectively.

predicted by the Lerner index, companies with a larger market share have smaller estimated marginal costs. Given that firm-level marginal costs are not observable, the best that we can do is to contrast our estimates with their lower bound—the cost of feed plus the cost of chicks required to produce one pound of RTC broiler meat.[19] Based on our calculation, the lower bound for marginal cost is 65 cents per pound of RTC broiler meat. The results show that all our estimates are significantly above the lower bound.[20]

In fact, we can use marginal cost to argue that a Cournot model with a competitive fringe is better than the standard Cournot model. Based on the Lerner index in Equation (6), as there is no competitive fringe, the elasticity of the residual demand on the right hand side of (6) is now the elasticity of the entire market demand. Plugging in different firms' market shares, one can compute their price cost margins and, since the price is common to all, their marginal costs. The results of such an exercise show that the marginal cost of, for example, Tyson Foods is 61 cents per pound of RTC broiler meat, which is lower than the minimum lower bound for the industry, which is shown to be 65 cents per pound of RTC broiler meat.

5 | MERGER SIMULATION

According to Davis and Garcés (2009), the general procedure of merger simulation involves the following steps: (1) make assumptions about consumer demand, production cost, and market structure; (2) either estimate or calibrate the demand function and marginal cost function; (3) establish how the merger influences the optimization conditions for each firm; and (4) compute the new equilibrium and compare it to the original one. Using the obtained estimates of the market demand function and the supply function of the competitive fringe, and defining the capital stock of the newly merged company as $\widehat{k}_m = \widehat{k}_3 + \widehat{k}_7$, we numerically solve the following system of equations using MATLAB:

$$\begin{cases} P = a - \widehat{b}_1 Q \\ Q = Q^r + Q^c \\ Q^c = \widehat{K}^c P \\ Q^r = \sum q_j = \sum \dfrac{1}{\dfrac{1}{P\widehat{k}_j} - \dfrac{\widehat{b}_1}{P - \widehat{b}_1 Q^c}} \end{cases}, \tag{17}$$

[19]The interested reader can find details about how the lower bound is calculated in Appendix C in the online supplementary appendix.
[20]Similar as before, the significance level is determined by calculating the 95% confidence intervals via bootstrap.

TABLE 8 Estimated merger effects: Percentage change in indicators.

	$N^r = 6$	95% CI	$N^r = 7$	95% CI
Average price	+1.18%**	[+0.25%, +2.23%]	+0.53%**	[+0.14%, +0.90%]
Total quantity	−0.57%**	[−0.58%, −0.38%]	−0.26%**	[−0.27%, −0.19%]
Q^{Tyson}	−0.27%**	[−0.51%, −0.05%]	+0.53%**	[+0.14%, +0.90%]
$Q^{Pilgrim}$	+0.016%	[−0.03%, +0.04%]	+0.53%**	[+0.14%, +0.90%]
$Q^{Sanderson+Wayne}$	−8.31%**	[−11.18%, −3.93%]	−5.94%**	[−8.11%, −2.83%]
Q^{Perdue}	+0.67%**	[+0.15%, +1.21%]	+0.53%**	[+0.14%, +0.90%]
Q^{Koch}	+0.75%**	[+0.17%, +1.36%]	+0.53%**	[+0.14%, +0.90%]
$Q^{Mountaire}$	+0.81%**	[+0.18%, +1.47%]	+0.53%**	[+0.14%, +0.90%]
Consumer surplus	−1.14%**	[−1.15%, −0.77%]	−0.51%**	[−0.55%, −0.38%]
Producer surplus	+9.60%**	[+7.93%, +11.50%]	+0.84%**	[+0.24%, +1.38%]
Total surplus	+1.57%	[−0.29%, +5.72%]	−0.15%	[−0.30%, +0.06%]

Note: *, **, and *** mean coefficients are significant at the 10%, 5%, and 1% significance level, respectively.

where $a = \widehat{b}_0 + \widehat{b}_2 Pork + \widehat{b}_3 \boldsymbol{D_m} + \widehat{b}_4 t + \widehat{b}_5 t^2$, and the last expression is derived from Equation (15).[21]

Besides the price and quantity effect, we are also interested in how the merger influences social welfare—consumer surplus, $CS = \int_0^{Q^*} (P(Q) - P^*) dQ$, and producer surplus of each strategic firm j, $PS_j = P^* q_j^* - \int_0^{q_j^*} MC_j(q_j) dq_j$—where * indicates equilibrium price and quantities. We assume that the demand curve will not be influenced by the merger, so the consumer surplus is negatively correlated with the equilibrium price and positively correlated with the equilibrium quantity. We also assume that the broiler industry is a constant cost industry such that, in the long run, the producer surplus of the competitive fringe equals 0. Therefore, the total surplus is defined as $TS = CS + \sum_{j=1}^{N^r} PS_j$.

The results presented in Table 8 clearly indicate that the merger effects on market equilibrium are sensitive to the choice of N^r. The price effect (+1.18%), quantity effect (−0.57%), consumer surplus effect (−1.14%), and producer surplus effect (+9.60%) when $N^r = 6$ are all much larger than the price effect (+0.53%), quantity effect (−0.26%), consumer surplus effect (−0.51%), and producer surplus effect (+0.84%) when $N^r = 7$. The corresponding 95% confidence intervals are also much wider in the former case. Even though the sizes of all these effects vary, they have the same sign and most of them are significant at the 5% level in both cases.[22] The aggregate welfare, defined as the sum of consumer surplus and oligopoly producer surplus, may increase by 1.57% when $N^r = 6$ or decrease by 0.15% when $N^r = 7$. However, the total welfare effect is not significant at the 5% significance level in both cases. The merger effect on firm-specific quantity also varies. For example, the quantity supplied by Tyson Foods may increase or decrease depending on the choice of N^r. However, in both cases, the quantity supplied by the newly merged company Wayne-Sanderson Farms will be smaller than the sum of the pre-merger supply of Sanderson Farms and Wayne Farms.

5.1 | Discussion of the Nocke-Whinston proposition

Nocke and Whinston (2022) relate the measure of concentration (HHI) to the required efficiency gain (required reduction in marginal cost) such that the merger will not harm consumers by

[21]The range of j depends on N^r. For $N^r = 6$, the No. 3 firm (Sanderson) is merged with the No. 7 firm (Wayne), but Wayne is a competitive firm, so there are six strategic firms after the merger. When $N^r = 7$, the No. 7 company (Wayne), which is in this case also a strategic company, ceases to exist and hence there are still only six strategic firms after the merger. The parameter a is calculated for each month of 2021.

[22]Because we are testing against $H_0 = 0$, the percent change in any given indicator is significant at the 5% level if its 95% confidence interval does not contain 0.

increasing the post-merger equilibrium market price. By assuming a standard Cournot model with a constant return to scale technology and constant marginal cost, they show that if firm i with market share s_i and marginal cost MC_i is combined with firm j with market share s_j and marginal cost MC_j, to guarantee that the merger is consumer-surplus-neutral, the required cost synergies should satisfy

$$\frac{\overline{MC}-MC_m}{\overline{MC}}=\frac{\left(\sqrt{\frac{\Delta H}{2}}\right)\left(\sqrt{2(1-H_m)}\right)}{-\epsilon+\left(\sqrt{\frac{\Delta H}{2}}\right)\left(\frac{H_m\sqrt{2}}{\sqrt{1-H_m}}\right)}, \tag{18}$$

where $\overline{MC}=\frac{s_iMC_i+s_jMC_j}{s_i+s_j}$, MC_m is the marginal cost of the newly merged company as if it still produces at the pre-merger level, $\Delta H=2s_is_j$, and $H_m=\frac{s_i^2+s_j^2}{(s_i+s_j)^2}$ is called the *within-merger* HHI. When Equation (18) holds, it means that the merger in question has no impact on market price and consumer surplus. If the post-merger marginal cost MC_m is not significantly smaller than $\overline{MC}$, then $LHS<RHS$ in Equation (18) and the cost synergy induced by the merger is not big enough to prevent the merger from raising the price and reducing the consumer surplus. The reverse is also true.

Since we are considering a Cournot model with competitive fringe, Equation (18) needs to be modified to accommodate the difference. Since solving the Cournot oligopoly with a competitive fringe model is equivalent to solving the standard Cournot model where Cournot players face the residual demand function, the required modification of Equation (18) amounts to setting $\overline{MC}=\frac{s_i^rMC_i+s_j^rMC_j}{s_i^r+s_j^r}$, $\Delta H^r=2s_i^rs_j^r$, $H_m^r=\frac{(s_i^r)^2+(s_j^r)^2}{(s_i^r+s_j^r)^2}$, and ϵ^r as the price elasticity of the residual demand. In summary, instead of using the price elasticity of the total demand (ϵ), we use the price elasticity of the residual demand ϵ^r and instead of using market shares, we use the relative shares within the oligopoly.[23]

When $N^r=7$, we find that $LHS=0.00033<0.056=RHS$, which means that the cost synergy is not big enough to neutralize the price increase. Hence, both the insight from the concentration-based threshold method and our merger simulation result suggest that the merger will cause harm to consumers by raising the market price.

6 | CONCLUSION

This article investigates the impact of the merger between Sanderson Farms and Wayne Farms on the downstream chicken market. Since there exist several large broiler companies and many other much smaller ones, we believe that a Cournot oligopoly with a competitive fringe is a good theoretical model for the broiler industry. Our findings reveal that the merger will likely increase chicken prices, reduce consumer surplus, and increase producer surplus, and the results are significant at the 5% level. However, the size of these effects varies based on the number of oligopoly players: they are much larger when $N^r=6$ compared to when $N^r=7$. The net welfare effect is ambiguous and insignificant.

Since consumer benefit is the major concern in antitrust regulation, we also propose a market concentration–based threshold method to determine whether a merger will benefit consumers. The advantage of this method is that it only relies on pre-merger information like relative market shares of ready-to-be-merged firms and the price elasticity of residual demand. Not surprisingly, the market

[23]Nocke and Whinston's (2022) proof for Equation (18) is built upon Proposition 1 in Farrell and Shapiro (1990). The formal proof of the modified Equation (18) is available from the authors upon request.

concentration–based threshold method also predicts that the aforementioned merger will inflict damage on consumers. In light of these results, it is somewhat surprising that the merger has been approved by the regulators.

There is one segment of the poultry business that could indirectly benefit from the Wayne-Sanderson merger. Nestled in the consent decree that settled the wage suppression allegations against Cargill, Sanderson Farms, and Wayne Farms is the agreement to end the use of tournaments to settle broiler contracts. For many years, poultry processors have contracted with farmers for the production of live birds. The companies deliver chicks and feed to the farms and then harvest the market-size chickens several weeks later. The performance of each grower is compared to the average performance of the entire group: the farmers with the heaviest birds and lowest cost of production are paid bonuses, and those with below-average performance are penalized. Farmers have long argued that the system is unfair because the companies control all critical inputs and can hence pre-determine the outcomes; for an extensive discussion of the topic, see Leegomonchai and Vukina (2005).

Several previous administrations tried and failed to challenge the tournament system through the federal rule-making process. However, last year, the wage suppression case included a claim that did not seem to fit with the rest of the allegations. In a case that primarily dealt with employee pay, the DOJ also alleged that Sanderson's and Wayne's use of the tournament system violated the Packers and Stockyards Act, an antitrust law that has historically fallen under the purview of the Department of Agriculture (Brown, 2023). As part of the consent decree, the defendants agreed to end the use of the tournament system. In the future, the newly formed Wayne-Sanderson Farms will pay growers a minimum base rate, and no grower with below-average performance will be paid less than the base piece rate per pound of live weight delivered.[24]

The Wayne-Sanderson Farms commitment to stop using the controversial tournament system as the mechanism for settling broiler production contracts and replace it with a less incentive-driven mechanism indicates that this merger could potentially benefit upstream suppliers of live chickens (i.e., contract farmers). The analysis of the merger effects on upstream suppliers would insert an important missing piece of the puzzle into the big picture of total merger effects assessment. A dynamic model similar to that in Benkard et al. (2010) could be adapted to estimate these effects. However, the availability of data on the exact locations of contract growers and companies that they contract with is the main obstacle to carrying out this investigation, so we leave it as a topic of future research.

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[24]The same issue is central to the new USDA proposed rule "The Poultry Grower Payment Systems and Capital Improvement Systems," which would, among other things, prohibit payment practices that reduce or discount payment rates in a contract under poultry grower ranking (tournaments) systems used in contract poultry production for broiler chickens. The comment period closed on August 9, 2024. Docket: AMS-FTPP-22-0046.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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