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RESEARCH ARTICLE

Consolidation, productivity, and downstream prices in the US poultry industry

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Abstract

Concentration in animal-based protein industries in the United States continues to garner the interest of policymakers, researchers, and consumers alike. We assess the impacts of industry concentration on animal productivity and downstream prices in the US broiler chicken industry between 1991 and 2019. We compile a dataset that matches annual, plant-level information on ownership and sales for all poultry processing facilities in the United States with market-level wholesale composite prices and bird yields. Consolidation over the last three decades has greatly contributed to industry concentration, leading to higher wholesale composite broiler prices (16.3%) and gains in animal productivity (2.4%).

Keywords: Animal productivity; concentration; consolidation; poultry industry; wholesale prices

JEL codes: Q13; L11

Introduction

Concentration and consolidation in animal-based protein industries in the United States remain a tantamount concern to policymakers, consumers, and researchers (e.g., Crespi and Saitone (2018); McKendree, Saitone, and Schaefer (2021)).[1] Amid ongoing policy discussions and academic research on market concentration, a key question remains: Does consolidation in the broiler industry primarily enhance productive efficiency through economies of scale, or does it lead to higher prices due to increased market power? While economic theory suggests that both forces may be at play, the net effect is an empirical

[1]Throughout this manuscript, we distinguish between consolidation – the process of firm ownership changes due to mergers and acquisitions – and concentration, which refers to the degree of market control held by the largest firms. While consolidation often leads to increased concentration, the two are not synonymous: firm exits, new entrants, and changes in market structure can influence concentration independently of merger activity.

question. This study evaluates how ownership consolidation in the US broiler industry has influenced two key market outcomes: broiler yield (as a measure of productive efficiency) and wholesale composite broiler prices (as an indicator of potential pricing power).[2]

In the realm of animal-based protein, substantial research attention has been focused on the impacts of consolidation and concentration in the beef and pork processing industries.[3] Despite experiencing many of the same trends in horizontal concentration, the broiler chicken processing industry has been subject to comparatively little research inquiry.[4] In this paper, we attempt to begin to fill this void in the literature by evaluating how increased levels of ownership concentration in the US broiler industry has impacted production efficiency (as measured by broiler yield improvements) and allocative inefficiency (as measured by downstream market prices) during the period 1991–2019.

Over the 50 years, spanning 1950–2000, the broiler industry has undergone a significant transformation. The structure of today's broiler industry was borne out of the 1950s and 1960s when firms became vertically integrated, built production complexes (i.e., hatcheries, feed mills, processing facilities), and devised a system wherein birds were raised by growers via "grow-out" production contracts (MacDonald and McBride, 2009). During this same period of time, broiler grow-out operations and poultry slaughter plants became much larger as compared to their historical counterparts (MacDonald et al., 2000; Ollinger et al., 2005).[5]

Concomitant with these organizational changes has been an increase in industry concentration.[6] During the period from 1982 to 2002, the top four broiler firms had a five-fold increase in production (as measured by ready-to-cook pounds of chicken), a three-fold increase in the number of processing plants, and four- and eight-firm concentration ratio increases of 27.9%–48.2% and 44.1%–66.6%, respectively (Goodwin, 2005). The period from 1997 to 2007 was characterized by intense merger and acquisition activity, with the vast majority of acquiring firms being large publicly traded entities (Weng, Vukina, and Zheng, 2015).[7] By 2020, the combined market share of the 10 largest broiler processors was approximately 80%, and the combined market share of the two largest companies, Tyson Foods and Pilgrim's Pride (JBS USA), was nearly 37% (Bolotova, 2022). Figure 1 shows how the 4-, 8-, and 20-firm concentration ratios have changed over the

[2]While these results provide insight into the consequences of consolidation, we do not attempt to directly assess overall social welfare effects, as that would require additional modeling of consumer surplus, producer surplus, and input price changes.

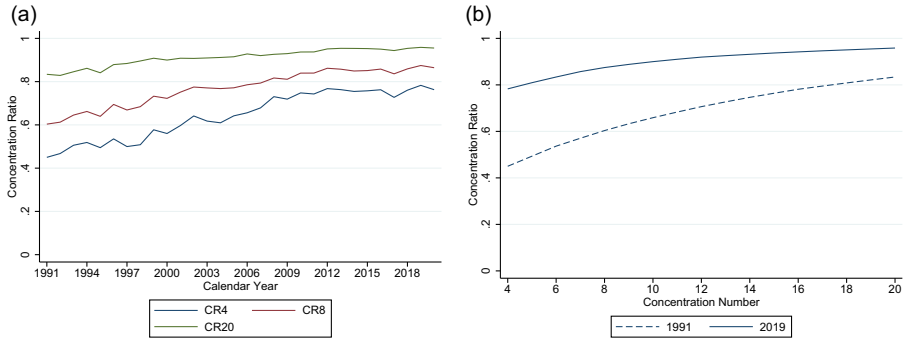
[3]See Azzam and Anderson (1996), Ward (2002), and Wohlgenant (2013) for summaries of the existing literature on the exercise of market power in US meatpacking.

[4]The majority of the research evaluating the impacts of market power in the broiler industry have focused on processors' potential exercise of monopsony power when engaging in production contracts with broiler growers (e.g., MacDonald and Key (2012)). This aspect of the potential exercise of market power is not considered directly in this paper.

[5]In 1959, less than 30% of broiler production originated on farms with 100,000 birds or more. By 2001, virtually all broiler production occurs on farms that raise more than 100,000 birds (MacDonald and McBride, 2009).

[6]Market concentration can be measured at different geographic levels. Country-level concentration refers to the national market share held by the largest firms (e.g., CR4, CR8 ratios), while local-level concentration reflects the degree of dominance within a specific region. In the broiler industry, production is geographically clustered – particularly in the Southeastern Unites States – which means that national-level concentration trends may not fully capture localized competition dynamics.

[7]In 2009, JBS SA acquired Pilgrim's Pride, making JBS the second largest broiler processor in the United States (Bolotova, 2022).



Concentration over Time

Distribution of Concentration

Figure 1. Evolution of concentration in the US poultry industry.
Notes: Panel (a) plots the CR-4, CR-8, and CR-20 from 1991 to 2019. Panel (b) compares concentration levels in 1991 versus 2019 across the range CR-4 to CR-20. These data are constructed by the authors using plant-level data from the *National Establishment Time Series* (NETS) for all poultry processing facilities in the United States from 1991 to 2019.

period of 1991–2019. Historical trends in ownership consolidation have also precipitated increased scrutiny of current and future mergers/acquisitions.[8]

In this paper, we assess how ownership consolidation in the US broiler industry has affected productive efficiency and wholesale price levels over the last three decades.[9] Using National Establishment Time-Series (NETS) Data, which provide processing plant-level sales and ownership information, and market-level wholesale composite broiler prices and broiler yield data, we estimate that consolidation in the broiler industry increased wholesale prices by 16.3% while simultaneously contributing to productive efficiency, in the form of increased broiler yields, by 2.4%.[10]

The remainder of the paper is organized as follows. Section 2 provides relevant industry background. Section 3 presents a conceptual framework to demonstrate how the effects of consolidation on productivity and downstream prices are shaped by competing economic forces. In Section 4.1, we explain our vector autoregression (VAR) modeling approach to empirically test these relationships. Section 4.2 explains how we determine the contribution of firm consolidation on ownership concentration over time. Section 4.3 demonstrates how we integrate the findings of these analyses to reverse engineer the wholesale price and animal productivity outcomes that would have occurred without consolidation. Section 5 presents and discusses the results, and Section 6 concludes with a discussion and policy recommendations.

[8]A contemporary example is the Department of Justice investigation that precipitated the merger of Sanderson Farms (the third largest poultry processor in the United States) and Wayne Foods (the seventh largest poultry processor). Post-merger, the firm is roughly 15% of the broiler chicken industry.

[9]Our analysis does not attempt to evaluate total welfare implications but instead focuses on estimating the net effect of consolidation on productivity and downstream prices, which are key components of broader welfare considerations.

[10]The NETS data provide each processing facility's headquarters (i.e., ownership proxy) on an annual basis as well as address and FIPS code information. Using these data, we are able to assess the frequency of plant-level ownership changes.

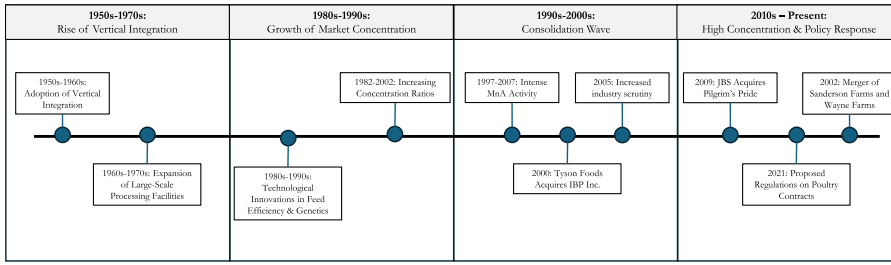


Figure 2. Key events in US broiler industry consolidation.
Notes: This timeline highlights major industry changes that contributed to increasing concentration in the US broiler sector. Key developments include the adoption of vertical integration in the 1950s–1960s, technological advancements in feed efficiency and genetics, a wave of mergers and acquisitions from 1997 to 2007, and regulatory responses in the 2020s.

Industry background

The broiler industry in the United States is a vertically integrated system of production, processing, and distribution. Broiler companies (i.e., integrators) typically coordinate operations through regional divisions that operate a hatchery, feed mill, transportation services, and slaughter plant (Weng, Vukina, and Zheng, 2015). Integrators use production contracts – agreements in which growers are paid to raise birds owned by the integrator under strict production guidelines – to engage independent broiler growers to raise birds for slaughter. These contracts specify input provisions (e.g., chicks, feed, veterinary services) and performance-based compensation structures, typically based on efficiency metrics such as feed conversion rates and mortality rates.

Broiler firms provide contract growers with chicks, feed, veterinary services, and technical assistance, as well as catching and transportation services.[11] By controlling all aspects of the production process, companies are able to achieve a steady flow of uniform birds to their processing facilities. Costs associated with transportation and the potential for bird morbidity serve to create localized markets where broilers are primarily raised within 60 miles of the processing facility with which they are contracted (MacDonald, 2014). Over time, industry consolidation, technological advancements, and vertical integration have further concentrated production within a small number of large firms, as shown in Figure 2.

Broiler processing facilities

In 1959, there was a total of 592 broiler processing facilities in the United States (Roy, 1966). Since that time, the number of processing facilities has declined while total broiler production has increased. By the 1980s, only 359 poultry slaughter plants remained in operation (Nguyen and Ollinger, 2009). This trend of fewer, larger processing facilities has continued; at the beginning of our study period (1991), there were 262 broiler processing plants in operation. Thirty years later – the end of the study period in 2019 – only 245 broiler processing facilities remained in operation.

[11]Grower pay is pegged to performance metrics (e.g., mortality, feed conversion) relative to other growers who deliver birds ready for harvest in the same week (MacDonald, 2014).

Production efficiency

The broiler industry has significantly improved its production efficiency. In 1955, it took 73 days to produce the average broiler, which weighed 3.1 pounds, and every 100 pounds of broiler production required 285 pounds of feed and 4 hours of labor (MacDonald, 2014). By 1980, production times were reduced to 52 days to grow a 4-pound bird, and every 100 pounds of broiler meat required 208 pounds of feed and 30 minutes of labor (Lasley, 1983). Genetic improvements reduced age to market by 57% and feed per pound of weight gain by 53% while increasing market weight by nearly 61% from 1925 to 1990 (Martinez, 1999).

The broiler industry's distinctive organizational structure has been proffered to have aided in its productivity and output growth (e.g., Knoeber (1989); Lasley (1983). Knoeber (1989) argues that the use of production contracts in the United States was part of the reason the real price of chicken fell by 54% from 1955 to 1980.[12] By 1990, more than 90% of the broiler industry had adopted production contracts as a means by which to grow broiler chickens. This suggests that the efficiency gains sourced with the conversion to production contracts had been realized before the start of our study period.

Conceptual framework

Industry consolidation in the US broiler sector has been driven by several structural and economic forces, including vertical integration, economies of scale, and technological advancements. However, the effects of consolidation on productivity and downstream prices are complex and are shaped by competing economic forces. As illustrated in Figure 3, consolidation can lead to both efficiency gains and increased market power, influencing pricing and productivity outcomes.

Competing effects of industry consolidation

The economic literature identifies two primary mechanisms through which consolidation affects industry performance:

1. **Efficiency Gains and Economies of Scale:** Larger firms can reduce per-unit production costs by spreading fixed costs over greater output, leading to efficiency gains. In the broiler industry, economies of scale have historically been achieved through vertically integrated production systems, centralized processing facilities, and automation. These cost reductions may result in downward pressure on wholesale prices.
2. **Market Power and Pricing Effects:** As firms consolidate, they gain greater control over pricing, potentially allowing them to exercise oligopoly power in the wholesale market. Increased concentration can also lead to oligopsony power in upstream markets, affecting input suppliers such as independent contract growers. This can contribute to higher wholesale prices, as fewer firms control market supply and can set prices above competitive levels.

[12]Broiler prices rose by far less than feed prices between 1960 and 1995, as steady improvements in feed conversion offset the effects of feed price increase (MacDonald, 2008).

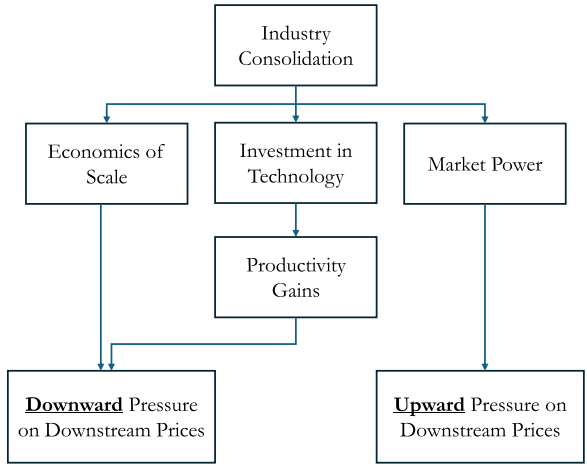


Figure 3. Conceptual framework – competing effects of consolidation.
Notes: This framework illustrates the dual effects of industry consolidation on productivity and downstream prices. Consolidation can lead to economies of scale, reducing production costs and potentially lowering prices. Simultaneously, firms may invest in technology, driving productivity gains. However, increased market power can enable firms to raise prices, exerting upward pressure on downstream prices. The net effect depends on the relative strength of these competing forces.

The role of investment in technology

In addition to economies of scale and market power, investment in technology serves as an independent driver of industry performance. Large firms often have greater financial resources to invest in genetic improvements, leading to faster growth rates and improved feed conversion efficiency and processing automation, reducing labor costs and increasing throughput. These technological advancements contribute to productivity gains, which may enhance overall industry efficiency. However, the extent to which these gains are passed to consumers or retained as higher profit margins depends on the relative influence of competitive forces.

Market concentration and productivity

The relationship between market concentration and productivity is complex and has been widely debated in the industrial organization literature. Broadly, two competing perspectives emerge (Daskalova et al., 2020; Nes, Colen, and Ciaian, 2024):

1. **The Technology Advancement and Superfirm Hypothesis:** This view suggests that larger firms achieve higher productivity due to their ability to invest in research and development (R& D), advanced technology, and economies of scale. Larger firms in concentrated industries often have greater financial capacity to implement efficiency-enhancing innovations, such as genetic improvements in broiler production, automation in processing plants, and data-driven optimization of supply chains. In this framework, market

concentration can drive efficiency gains, benefiting both producers and consumers if cost reductions lead to lower prices.

2. **The Barrier-to-Entry and Market Power Hypothesis:** In contrast, an alternative perspective suggests that as firms gain market dominance, competitive pressures weaken, reducing incentives for productivity-enhancing innovations. High concentration can create barriers to entry that limit the emergence of new, more efficient competitors, potentially leading to stagnation or rent-seeking behavior rather than further productivity improvements. If this dynamic dominates, consolidation may result in higher prices without proportional gains in productivity – raising concerns about long-term market efficiency.

The net effect of consolidation on productivity and prices is thus an empirical question, shaped by industry-specific factors such as technological adoption rates, supply chain structure, and regulatory oversight. The following analysis assesses whether the US broiler industry's consolidation over the last three decades has primarily enhanced efficiency through economies of scale and technology adoption or reinforced market power, leading to higher wholesale prices without proportional productivity gains.

Implications for the empirical analysis

This framework highlights the ambiguous effect of consolidation on market outcomes. If efficiency gains dominate, we would expect higher productivity and stable or lower prices. If market power dominates, we would expect higher prices without proportional productivity gains. The empirical analysis that follows tests these competing hypotheses by estimating the net effects of consolidation on productivity and wholesale prices in the US broiler industry from 1991 to 2019.

Methodology

This research assesses the impacts of consolidation on industry concentration, animal productivity, and downstream prices in the US broiler industry between 1991 and 2019. To do so, we compile a dataset that matches annual, plant-level information on ownership and sales for all poultry processing facilities in the United States with market-level wholesale composite prices and (live) bird yields, as well as various supply and demand shifters. We conduct our analysis in three steps:

1. First, we use VAR modeling to assess the dynamic relationship between increased concentration, market prices, and animal productivity.
2. Second, we use information on changes in plant-level headquarters over time to gauge the contribution of firm consolidation on increased ownership concentration over the period of analysis.
3. Finally, we combine the results of steps (1) and (2) to simulate the wholesale price and animal productivity outcomes that would have been observed in the absence of consolidation.

Vector autoregression (VAR) modeling

We use a VAR model to measure the dynamic relationship between market concentration, wholesale composite prices, and animal yields. Our specification allows market concentration, wholesale prices, and animal productivity to move together according to a long-run equilibrium. However, in each period, each variable experiences an exogenous shock. A desirable component of this approach is that the extent and speed at which prices and animal yields adjust to changes in concentration are accounted for in the VAR adjustment parameters (Beeler et al., 2023).

Our VAR representation is as follows:

$$P_t = \alpha^P + \delta^P P_{t-1} + \phi^P Y_{t-1} + \lambda^P CR_{t-1} + \mathbf{X}_t'\Omega^P + e_t^P \tag{1}$$

$$Y_t = \alpha^Y + \delta^Y P_{t-1} + \phi^Y Y_{t-1} + \lambda^Y CR_{t-1} + \mathbf{X}_t'\Omega^Y + e_t^Y \tag{2}$$

$$CR_t = \alpha^{CR} + \delta^{CR} P_{t-1} + \phi^{CR} Y_{t-1} + \gamma^{CR} CR_{t-1} + \mathbf{X}_t'\Omega^{CR} + e_t^{CR} \tag{3}$$

where P_t is defined as the wholesale composite broiler price (expressed in per retail pound) observed in period t. Variable Y_t is the federally inspected average live weight for broilers (in pounds), and variable CR_t is the concentration ratio. For our baseline specification, we use the CR-4 (i.e., the share of industry sales that are generated by the four largest firms) for our concentration ratio. We then consider the robustness and generalizability of our results across a range of CR measures from CR-4 to CR-20.

Vector $\mathbf{X}$ is a set of exogenous supply and demand shifters. On the supply side, we include the weighted-average farm price for corn (in $ per bushel) and the West Texas Intermediate (WTI) price for crude oil (in $ per barrel).[13] Consistent with prior literature (Carter, Schaefer and Scheitrum, 2021; Scheitrum, Schaefer, and Saitone, 2023), these variables are included because animal feed costs (proxied by the corn price) and energy costs (proxied by the WTI price) represent two of the greatest shares of production costs in animal production systems.

On the demand side, we include in vector $\mathbf{X}$ the consumer price index (CPI) for all urban consumers, seasonally adjusted and indexed with base years 1982–1984 (CPIAUCSL). We also include the wholesale-to-retail price markup (in per retail pound) as an exogenous control. This variable accounts for rising costs for value added and the fact that the retail food sector has experienced increased consolidation and concentration over the period of analysis (Marsh and Brester, 2004; Zeballos, Dong, and Islamaj, 2023). Increased downstream oligopsony power (proxied by the wholesale-to-retail markup) could at least partially offset the ability of broiler integrators to exploit increased oligopoly power when marketing chicken. Finally, we included in vector $\mathbf{X}$ a series of 11 indicators for the month of the year (with base month January) to account for seasonality in prices or animal yields.

We specify the model lag structure as prescribed by the Schwarz-Bayes information criterion (Schwarz, 1978). After estimating, we test the stability of our VAR parameters (Lütkepohl, Krätzig, and Phillips, 2004) and report residual-based Augmented Dickey-Fuller (ADF) (Dickey and Fuller, 1979) and Phillips-Perron (Phillips and Perron, 1988) tests for equations (1)–(3) to assess potential concerns of spurious correlation versus cointegration.

The concentration ratio data used in the estimation of equations (1)–(3) are as reported in Figure 1. Figure 4 shows the wholesale composite prices, bird yields, and supply and demand shifters used to estimate equations (1)–(3). Wholesale composite

[13]This is a spot price at delivery point Cushing, Oklahoma.

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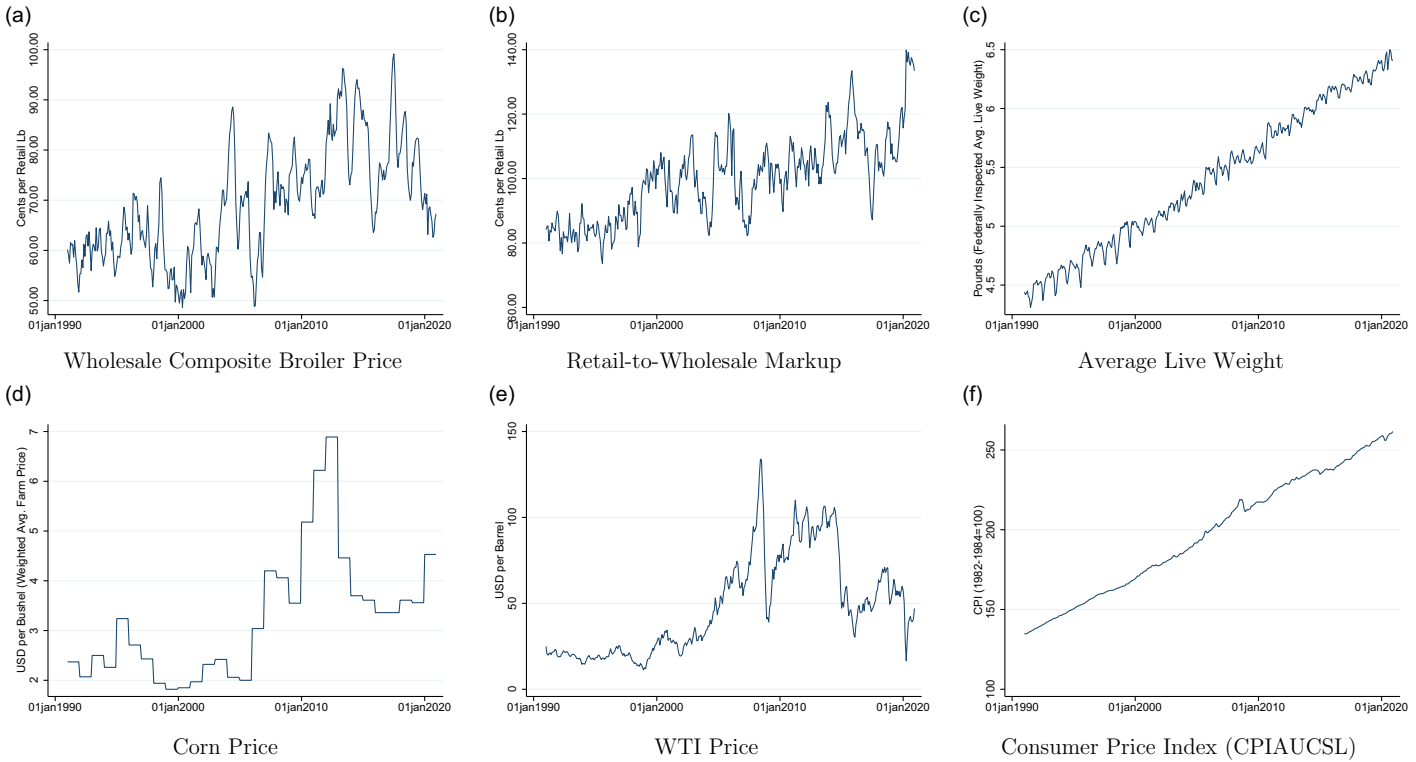


Figure 4. Composite prices, bird yields, and supply and demand shifters.

Notes: The figure shows the wholesale composite prices, bird yields, and supply and demand shifters used for VAR estimation. Wholesale composite broiler price data, wholesale-to-retail markup data, average weights for federally inspected broilers (in live pounds), and annual average corn prices are obtained from the USDA Economic Research Service. WTI crude oil prices are spot prices for delivery at Cushing, Oklahoma, obtained from the Energy Information Administration (EIA). The CPIAUCSL in panel (e) is obtained from the Federal Reserve Economic Data (FRED) from the St. Louis Federal Reserve.

broiler price data and wholesale-to-retail markup data shown in panel (a) of the figure are obtained from the US Department of Agriculture's (USDA) Economic Research Service (ERS) "Historical monthly price spread for beef, pork, broilers."[14] Monthly data on average weights for federally inspected broilers (in live pounds) shown in panel (b) of Figure 4 were obtained from the USDA ERS "Meat Statistics."[15] Annual average corn prices in panel (c) of the figure are obtained from the USDA ERS "Feed Grains Yearbook"[16] and are matched to the price and live weight data on an annual basis. WTI crude oil prices in panel (d) are spot prices ($ per million barrel) for delivery at Cushing, Oklahoma, obtained from the Energy Information Administration. The CPIAUCSL in panel (e) is obtained from the Federal Reserve Economic Data from the St. Louis Federal Reserve.

Contribution of consolidation to industry concentration

After estimating the dynamic relationship between concentration, animal productivity, and downstream prices in the US broiler industry, we next determine the contribution of firm consolidation on increased ownership concentration over the period of analysis. To do so, we use plant-level data from the NETS for all poultry processing facilities in the United States from 1991 to 2019.[17] This dataset contains a unique identification number (known as the DUNS number), as well as ownership and sales for each processing plant in each year of the analysis.[18] The NETS data also contain information on whether the plant is independently owned or is a subsidiary of another firm. If the firm is a subsidiary of another firm, the data include the unique DUNS identification number of the owner firm. This allows us to determine whether and when each processing plant changed owners over our time horizon.

To gauge the contribution of firm consolidation on increased ownership concentration over time, we conduct the following thought experiment: For each poultry processing plant i that has existed (at some point) over our period of analysis, denote the owner of the plant in period t as O_{it}. Further, denote the initial owner of the processing plant as O_{i0}. For plants that were in operation as of 1991, O_{i0} corresponds to the observed owner in 1991. For plants that began operation after 1991, O_{i0} corresponds to the owner in the year the plant first operational.

If consolidation had not occurred and plants did not change hands, the owner of each plant would remain as O_{i0} over the period of analysis. Thus, we construct counterfactual concentration ratios under a "no consolidation" scenario, where the "no consolidation" concentration ratio for the top N owners in a given year t is evaluated by assigning the sales of the plants operating in that year to the plants' initial owners O_{i0}. Accordingly, the contribution of consolidation to industry concentration is assessed as the difference

[14]These data are accessible at https://www.ers.usda.gov/webdocs/DataFiles/52160/history.xls.

[15]These data are accessible at https://www.ers.usda.gov/data-products/livestock-and-meat-domestic-data/.

[16]These data are accessible at https://www.ers.usda.gov/data-products/feed-grains-database/feed-grains-yearbook-tables/.

[17]Poultry processing facilities are identified based on the 8-digit Standard Industrial Classification (SIC) codes 2015000, 20150100, 20150106, 20150600, and 20150608.

[18]Note that this includes all processing plants that existed in any year over the period of analysis. So, the NETS data include observations for plants that have existed for the full time horizon, as well as firms that entered or exited at some point over the duration of the analysis.

between the actual concentration ratio in that year and the counterfactual "no consolidation" concentration ratio in that year.[19]

Figure 5 plots the locations of plants owned by the top-4 firms in 1991 versus 2019, alongside plants owned by firms outside the top four. Figure 6 presents further summary statistics for the plant-level data used in this analysis. Our analysis includes information from 522 unique poultry processing facilities and 307 unique owners. The average processing facility had annual sales of $4.3 million, and the average owner had annual sales of $8.36 million over the period of analysis. For each owner that was operational over the full time horizon, panel (a) of Figure 6 shows total sales for the owner in 1991 (on the horizontal axis) versus 2019 (on the vertical axis), expressed in natural logarithmic form. Owners that expanded production lie above the dotted line, and those that reduced production lie below the dotted line. Panel (b) of the figure shows the distribution of sales for each owner on an annual basis.

Counterfactual simulations

We combine the results of the analyses in Sections 4.1 and 4.2 to simulate the wholesale price and animal productivity outcomes that would have been observed in the absence of consolidation. To do so, we begin with the actual observations for all VAR variables from January 1991. Then, using the estimated dynamic equilibrium relationships obtained from fitting equations (1)–(3), we project forward the time path for wholesale prices and animal yields under the assumption that the CR-4 (or an alternative CR measure in the robustness analysis) would have followed its counterfactual trajectory under the "no consolidation" scenario as estimated in Section 4.2. We attribute the difference between actual prices and yields and those that we observe under this simulated "no consolidation" scenario as the impacts of consolidation on wholesale prices and animal productivity.

Results

Section 5.1 presents our baseline results. In Section 5.2, we assess the robustness of these findings to alternative constructions of our concentration variable.

Baseline results

VAR analysis

VAR parameter estimates describing the dynamic equilibrium relationship between market concentration, wholesale composite prices, and animal yields are shown in Table 1. Point estimates are generally consistent with expectations. Lagged dependent variables in Columns (1), (2), and (3) are all statistically significant at the 1% level and are all relatively close in magnitude to one. This aligns with the fact that we fail to reject unit root processes for each of the variables of interest in the model. Residual-based ADF and Phillips-Perron tests confirm that the systems are co-integrated. Under both tests, we reject the null hypothesis of non-stationarity in the residual for each model at the 1% level of statistical

[19]This is not a perfect approximation. For example, some plants may have undergone expansions, renovations, and other improvements due to consolidation. Thus, because of consolidation, their sales are larger than they otherwise would have been. On the other hand, some owners have been known to purchase processing plants and proceeded to close those plants (or anothers in their arsenal). Had the owners not purchased these plants, these closures may not have happened. Our analysis does not account for these post-consolidation changes in sales.

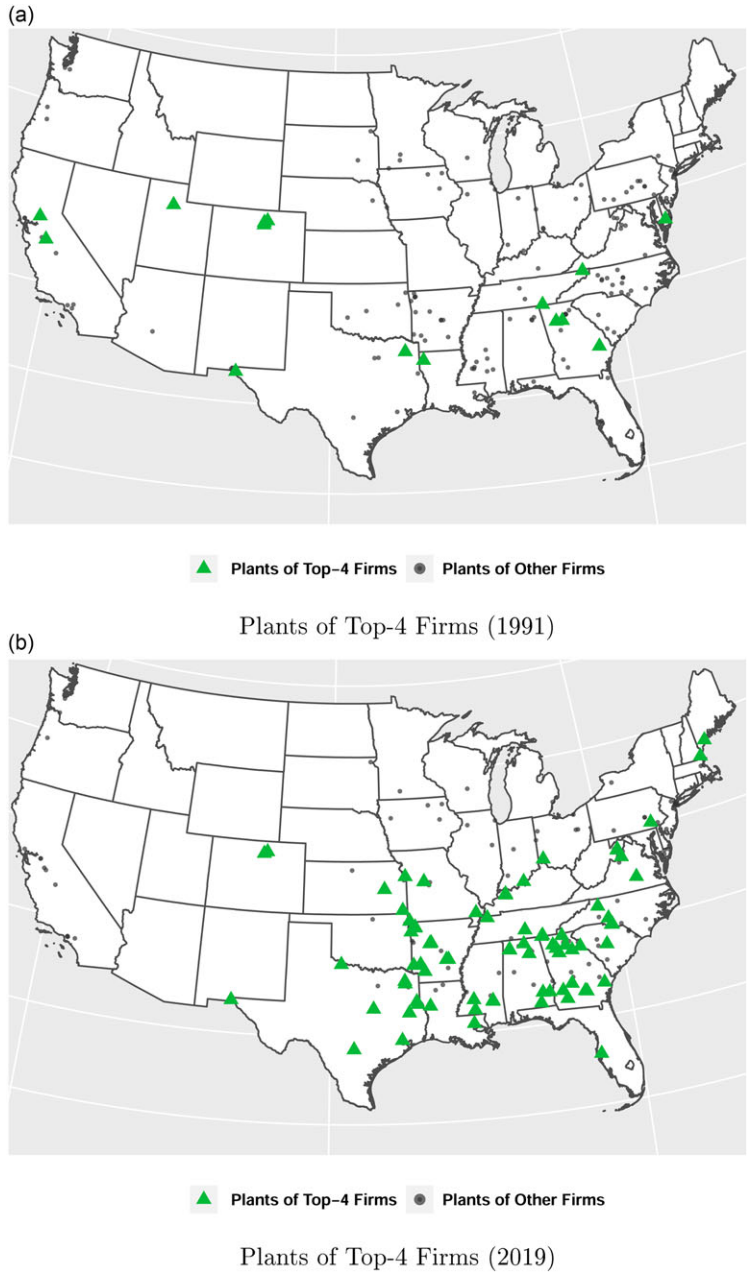
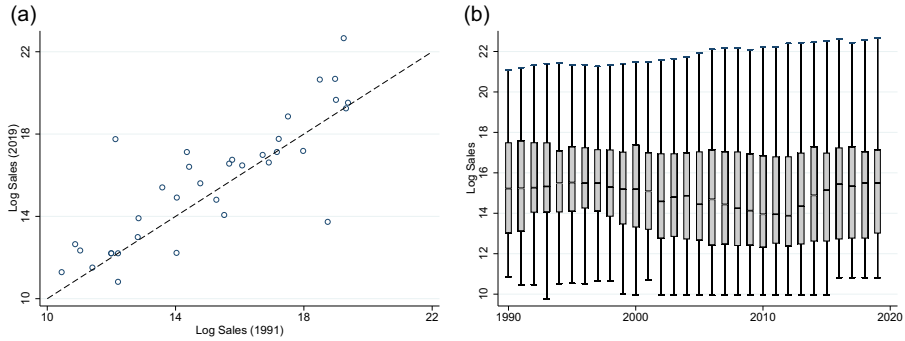


Figure 5. Broiler processing plant locations, 1991 versus 2019.
Notes: Panel (a) plots the locations of all broiler processing plants in 1991. Panel (b) plots the locations of all broiler processing plants in 2019. In both panels, plants owned by the top-4 firms are depicted with a green triangle. Plants owned by firms outside of the top four are depicted with gray dots.



Evolution of Sales, by Owner

Distribution of Annual Sales, by Owner

Figure 6. Consolidation and concentration – summary statistics.
Notes: The figure presents summary statistics for the plant-level data used in this analysis. For each owner that was operational over the full time horizon, panel (a) shows total sales for the owner in 1991 (on the horizontal axis) versus 2019 (on the vertical axis), expressed in natural logarithmic form. Panel (b) shows the distribution of sales for each owner on an annual basis.

significance. Additionally, our VAR estimates satisfy tests for parameter stability and covariance stationarity (Lütkepohl, Krätzig, and Phillips, 2004).[20]

Referring to Column (1) of the table, we see that an increase in animal productivity – holding concentration levels constant – leads to a reduction in downstream prices (statistically significant at the 5% level). The point estimate for the short-run elasticity suggests that a 1% increase in broiler live weights corresponds to a 0.50% reduction in the wholesale price. This is consistent with the observed decline in the real price of chicken in the United States that persisted from 1955 to 1980 (Knoeber, 1989). In contrast, an increase in CR-4 – holding animal yields constant – leads to an increase in downstream prices (statistically significant at the 1% level). The short-run concentration-to-price elasticity is 0.26, meaning a 1% increase in industry concentration corresponds to a 0.26% increase in wholesale prices. With respect to our exogenous controls, we see that an increase in CPI is positively correlated (and statistically significant at the 1% level) with wholesale prices. In contrast, an increase in the retail markup is associated with a drop in the wholesale price (statistically significant at the 1% level). This is consistent with the hypothesis that increases in buyer power at the retail level may have an offsetting effect on the ability of broiler processors to exploit market power associated with increased levels of concentration.

Referring to Column (2), we see that an increase in wholesale prices is also associated with an increase in animal yields. When processors observe higher prices, they may be incentivized to delay slaughter in order to increase bird size. The point estimate in Column (2) suggests the short-run price-to-yield elasticity is 0.01 (statistically significant at the 1% level). In contrast, an increase in the corn (feed) price is associated with a reduction in animal yields. As input costs rise, processors may be incentivized to slaughter broilers sooner to avoid growth periods associated with less efficient feed yields. Hamilton and Sunding (2021) show that because feed costs are incurred by vertically integrated

[20]In other words, estimated equations (1)–(3) satisfy the condition that the modulus of each eigenvalue in the companion matrix is less than one. See Appendix Figure A1.

Table 1. Estimated dynamic equilibrium relationship

	(1)	(2)	(3)
Variables	Price	Yield	CR-4
Ln Price (L1)	0.7837***	0.0102***	0.0005
	(0.0210)	(0.0036)	(0.0044)
Ln Yield (L1)	−0.4999**	0.7643***	0.0317
	(0.2098)	(0.0360)	(0.0442)
CR-4 (L1)	0.2565***	0.0224	0.9416***
	(0.0902)	(0.0155)	(0.0190)
Ln WTI	−0.0033	−0.0015	0.0020
	(0.0062)	(0.0011)	(0.0013)
Ln Corn	−0.0163*	−0.0037**	0.0015
	(0.0090)	(0.0015)	(0.0019)
CPI	0.0024***	0.0006***	0.0000
	(0.0006)	(0.0001)	(0.0001)
Ln Retail Markup	−0.3399***	0.0091	0.0027
	(0.0329)	(0.0056)	(0.0069)
Constant	2.7272***	0.1878***	−0.0318
	(0.2713)	(0.0465)	(0.0572)
Month Dummies (Jan = Base)	Yes	Yes	Yes
Observations	359	359	359
RMSE	0.04	0.01	0.01
Residual-based cointegration tests			
ADF Z(t)	−15.40	−17.45	−18.36
(*p*-value)	(0.00)	(0.00)	(0.00)
Phillips-Perron Z(t)	−15.77	−17.39	−18.38
(*p*-value)	(0.00)	(0.00)	(0.00)

Standard errors in parentheses.
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

processors, improved feed conversion serves to reduce integrator costs while also reducing the slope of the farm supply curve, effectively diminishing oligopsony power and creating a scenario where feed costs disproportionately impact integrator price-cost margins. The point estimates in Column (2) suggest that an increase in industry-level concentration is associated with improved animal yields, though this effect is insignificant. The VAR model suggests a short-run elasticity of 0.02 for this relationship.

Based on the parameter estimates in Table 1, Figure 7 plots the impulse response functions for wholesale composite broiler prices in panel (a) and live weight pounds in panel (b) responses over a 24-month period to a 1% increase in the CR-4. Consistent with

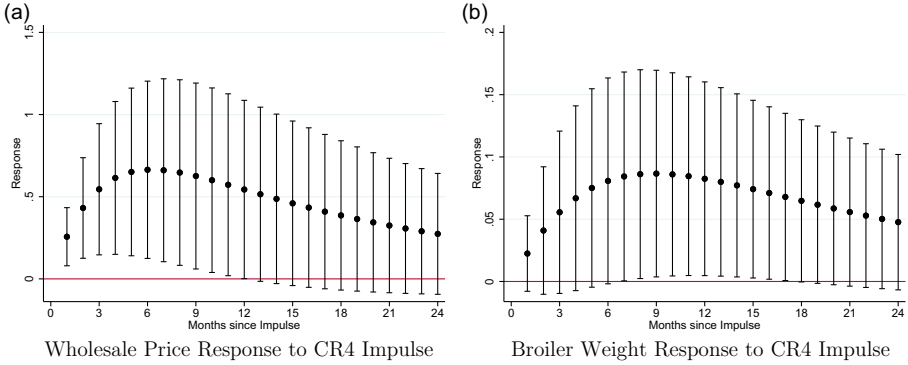


Figure 7. Impulse response functions.
Notes: Figure plots the impulse response functions (IRFs) – based on the parameter estimates in Table 1 – for wholesale composite broiler prices in panel (a) and live weight pounds in panel (b) responses over a 24-month period to a 1% increase in the CR-4.

the short-run elasticities in Table 1, both wholesale prices and animal yields increase over the following two years in response to an increase in concentration levels. In this respect, wholesale prices are substantially more responsive than animal yields. Two years after the 1% impulse to CR-4, the persistent impact is a 0.27% increase in wholesale prices and a 0.05% increase in broiler live weight. One likely explanation for this disproportionate impact is that some of the production efficiencies were realized before the beginning of our study period (1991) and thus are not part of the model estimates.

Contribution of consolidation to industry concentration

We find that consolidation in the US poultry industry over the last three decades has greatly contributed to industry concentration. Figure 8 plots the actual CR-4 observed over our time horizon versus the counterfactual CR-4 that would have been observed in the "no consolidation" scenario. This counterfactual is constructed as described in Section 4.2. In 2019 (the most recent year in our analysis), the actual CR-4 for the US poultry industry was 0.78. In the absence of consolidation, the CR-4 for 2019 would have been 0.60. In other words, industry consolidation between 1991 and 2019 led to a 30% increase in CR-4.

Counterfactual simulations

Integrating the results of the VAR analysis and the counterfactual CR-4 under the "no consolidation" scenario, as described in Section 4.3, we simulate the wholesale price and animal productivity outcomes that would have been observed in the absence of consolidation. The results of this analysis are shown in Figure 9. As shown in panel (a) of the figure, we find that consolidation has led to higher wholesale composite broiler prices. In December 2019 (the most recent period in our data), prices were 16.3% higher than they would have been if observed consolidation had not occurred. At the same time – as shown in panel (b) – consolidation has contributed to meaningful gains in animal productivity. We estimate that consolidation has directly increased animal yields by approximately 2.4% as of December 2019.

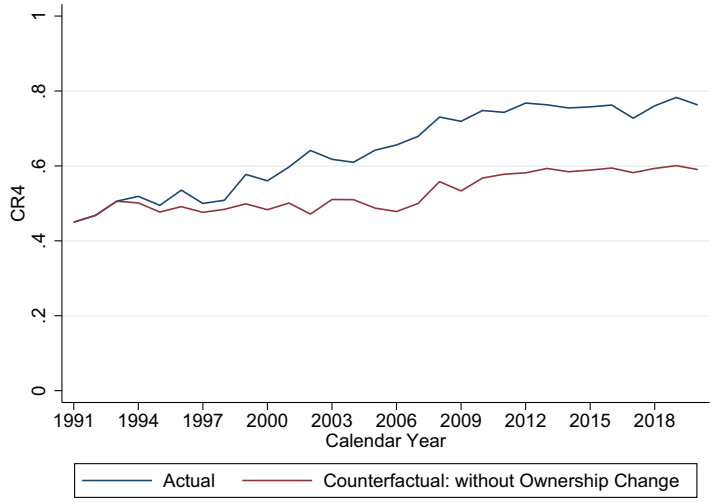


Figure 8. Counterfactual "no consolidation" concentration ratios.
Notes: Figure plots the actual CR-4 observed over our time horizon versus the counterfactual CR-4 that would have been observed in the "no consolidation" scenario. This counterfactual is constructed as described in Section 4.2.

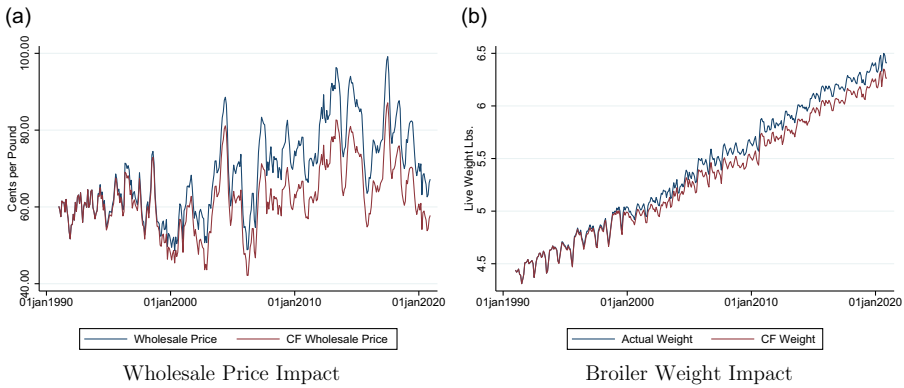


Figure 9. Contribution of consolidation to prices and productivity.
Notes: The figure shows actual wholesale prices (panel a) and broiler weights (panel b) versus counterfactual prices and bird weights that would have accrued in the absence of consolidation over the period of analysis. These results are obtained by integrating the results of the VAR analysis and the counterfactual CR-4 under the "no consolidation" scenario as described in Section 4.3.

Model robustness

In this section, we assess the robustness and generalizability of our baseline results to the use of the CR-4 as our measure of concentration. To do so, we re-run the analyses described in Section 4 using a range of concentration measures from CR-4 to CR-20.

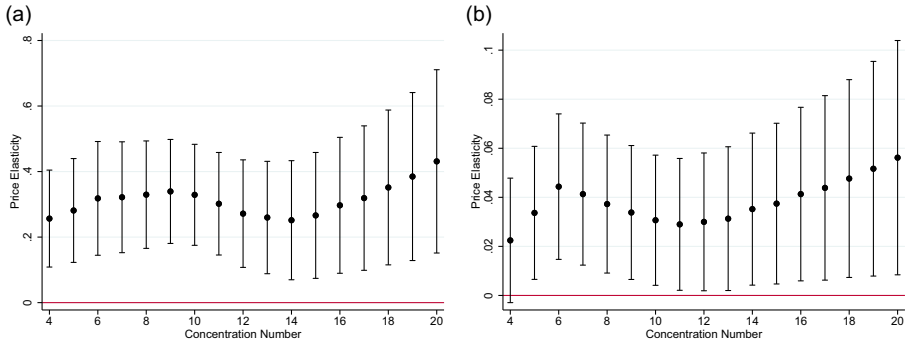


Figure 10. Short-run price and yield elasticities to increased CR-4–CR-20.
Notes: The figure plots the estimated short-run wholesale price and animal yield elasticities to increased concentration across the range CR-4 to CR-20 to assess the sensitivity of our CR-4-based results.

VAR analysis

Figure 10 plots the estimated short-run wholesale price and animal yield VAR elasticities to increased concentration across the range CR-4 to CR-20. These results are directly comparable to the CR-4 point estimate 0.2565 in Column (1) of Table 1 and the CR-4 point estimate 0.0024 in Column (2) of Table 1. Both the relationship between wholesale prices and concentration and the relationship between average bird weights and concentration are consistently positive across all specifications. Further, the relationships appear to grow in magnitude when we define concentration across a broader set of firms. When concentration is defined using the CR-8, the short-run elasticity for wholesale prices is 33.0 $\pm$ 19.2% and for bird weights is 3.7 $\pm$ 3.3%. When concentration is defined using the CR-20, the short-run elasticity of wholesale prices increases to 43.1 $\pm$ 17.1%, and the elasticity for bird weights increases to 5.6 $\pm$ 4.8%.

Contribution of consolidation to industry concentration

Figure 11 plots the percentage increase in CR-4 to CR-20 that is attributable to consolidation between 1991 and 2019. This impact estimate is obtained by comparing the actual CR over our time horizon versus the counterfactual CR that would have been observed in the "no consolidation" scenario, constructed as described in Section 4.2. We find that – in percentage terms – the impact of consolidation on our CR measures falls as the number of firms considered in the CR grows. For example, in 2019, the CR-8 (i.e., share of industry revenue generated by the top 8 firms) was 20.4% higher than it would have been had consolidation not happened over our sample period (87.5 in reality vs 72.7 in the "no consolidation" counterfactual). On the other hand, consolidation increased the CR-20 for year 2019 by just 6.9% (from 89.6 in the "no consolidation" scenario to 95.8 in reality). Thus, the percentage impacts we observe are partly due to the fact that the firms that engaged most with mergers and acquisitions were the largest firms. However, they are also explained by the fact that – at the CR-20 level – the industry was already highly concentrated as of 1991. So, in percentage terms, there was not much room for higher-level CR measures to increase.

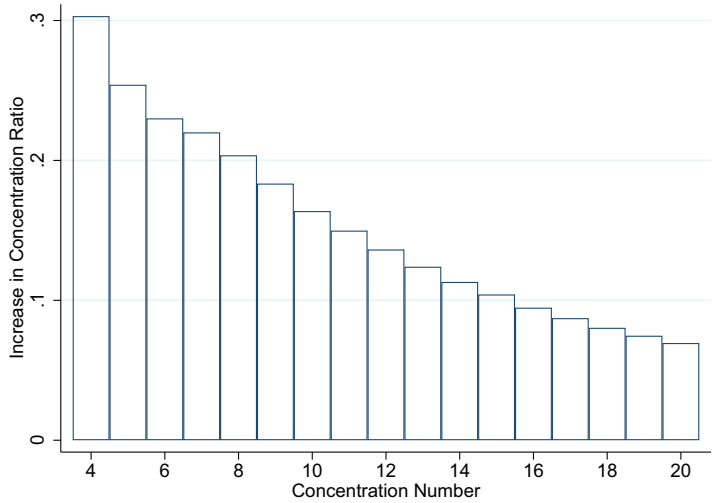


Figure 11. Impact of consolidation on CR-4–CR-20 (2019).
Notes: The figure plots the percentage increase in CR-4 to CR-20 that is attributable to consolidation between 1991 and 2019. This impact estimate is obtained by comparing the actual CR over our time horizon versus the counterfactual CR that would have been observed in the "no consolidation" scenario. This counterfactual is constructed as described in Section 4.2.

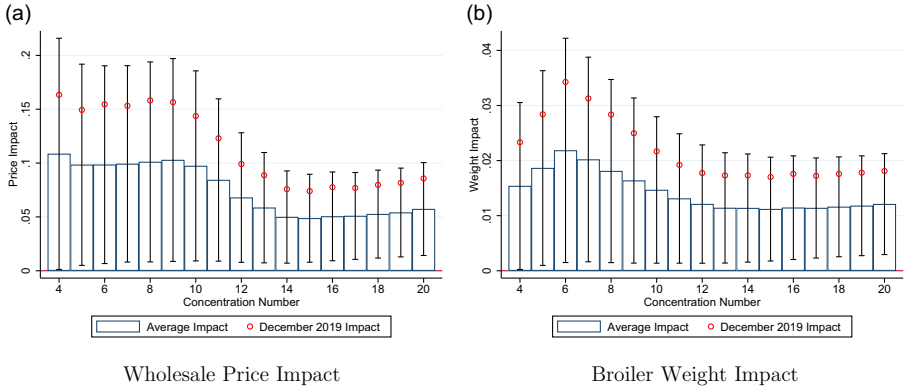


Figure 12. Robustness – contribution of consolidation to prices and productivity.
Notes: The figure shows the percentage impact of consolidation on wholesale broiler prices (panel a) and broiler weights (panel b) based on analyses using CR-4 to CR-20. The vertical bars show the average difference between actual and counterfactual prices and bird weights observed over the period of analysis. The red scatter dots show the impact as of December 2019 (the most recent month in our dataset).

Counterfactual simulations

Figure 12 shows the percentage impact of consolidation on wholesale broiler prices (panel a) and broiler weights (panel b). For both variables, estimated impacts are largest for CR-4 through CR-9 measures of concentration. This makes sense, considering the VAR

and "no consolidation" concentration measures described above. Referring to Figures 10 and 11, this is the region where prices and animal yields are fairly responsive to changes in concentration and where consolidation appears to have large impacts on consolidation over the period of analysis. On average, across all of our CR specifications, wholesale prices increased by 11.4%, and bird yields increased by 2.0% as of December 2019 as a result of consolidation. This is consistent with our baseline findings.

Conclusion and policy implications

Following the unrest in animal-based processing that occurred during the COVID-19 pandemic, there has been a renewed interest in the structure, conduct, and performance of all segments of the industry (e.g., Lusk, Tonsor, and Schulz (2021); Ramsey et al. (2021)). At the time, many argued that large, highly concentrated – both in terms of ownership and geography – processing operations were the cause of wide spread supply disruptions. Subsequent initiatives have been promulgated in order to incentivize the construction and operation of small- and mid-scale processing operations. This was done with seemingly little consideration given to the production efficiencies associated with large-scale operations and the likely benefits derived by consumers from economies of scale (Saitone, Schaefer, and Scheitrum, 2021).

Beyond those industry-focused initiatives, there have also been broader, economy-wide appeals to make firms more competitive. One particularly relevant example is Senate Bill (SB) 3847, the *Prohibiting Anticompetitive Mergers Act of 2022*. This bill is intended to (i) prohibit certain mergers (e.g., those valued at more than $5 billion in assets, those that result in the entity having greater than 33% market share), (ii) expand the authority of the Federal Trade Commission (FTC) and the Department of Justice (DOJ) to review pending mergers, and (iii) authorize the FTC and the DOJ to retroactively unwind mergers that are prohibited under the bill or that meet certain other anticompetitive criteria. This proposed SB and other efforts geared toward improving livestock industry competitiveness (e.g., President Biden's *Executive Order on Promoting Competition in the American Economy*) are likely to limit a continuation of the trend of ownership consolidation observed in the broiler chicken industry.

We find that consolidation over the last three decades has greatly contributed to industry concentration. In 2019, the CR-4 for the US poultry industry was 0.78. In the absence of consolidation, the CR-4 for 2019 would have been 0.60. This consolidation has led to higher wholesale composite broiler prices. In December 2019, prices were 16.3% higher than they would have been if observed consolidation had not occurred. At the same time, consolidation has contributed to meaningful gains in animal productivity. We estimate that consolidation has directly increased animal yields by approximately 2.4% as of December 2019. While renewed interest and focus on "competition-enhancing" policies may reduce the upward trend in wholesale prices sourced with higher levels of concentration, policymakers need to consider the possibility that limiting consolidation may also mitigate firms' willingness and ability to invest in innovation and achieve cost-reducing levels of economies of scale; the very type of activity that facilitated the broiler yield increases documented in this work.

Data availability statement. The data used to conduct this analysis are not publicly available and were obtained via a cooperative work agreement with the Office of the Chief Economist. The findings and conclusions in this article are those of the authors and do not represent any official US Department of Agriculture or US government determination or policy.

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Competing interests. The authors report no conflicting interests relevant to this work.

Ethical standard. This project did not involve human subjects research.

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Appendix

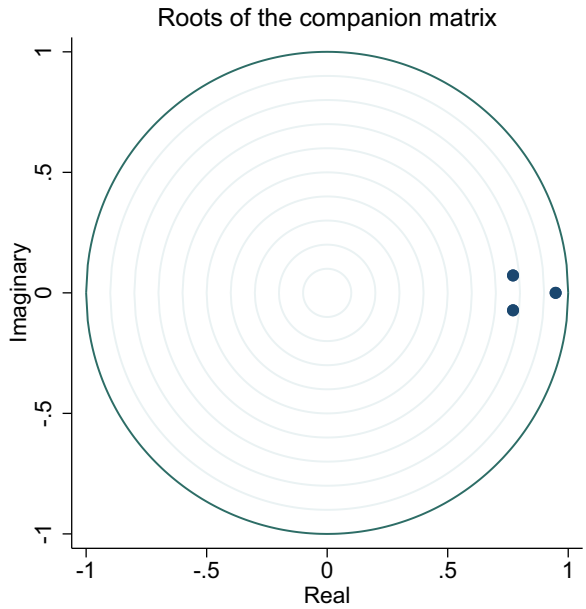

Figure A1. VAR parameter stability test.
Notes: This figure depicts the results for parameter stability and covariance stationarity (Lütkepohl, Krätzig, and Phillips, 2004). Estimated equations (1)–(3) satisfy the condition that the modulus of each eigenvalue in the companion matrix is less than one.

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