The Effects of U.S. Poultry Industry Consolidation on Employee Productivity and Wages

May 13, 2024

Abstract

Since Upton Sinclair's famous novel, *The Jungle*, was published in 1906, ownership concentration and workers rights and protections in the U.S. meat processing industry have been a highly charged topic. The passage of decades has done little to alleviate tensions. Most recently, the Department of Justice antitrust division has announced a monposony power investigation; an inquiry into the three of the largest U.S. poultry producers colluding to suppress employee wages. In this paper, we consider the relationship between concentration and worker wages at the industry level using plant-level data for all poultry processing facilities in the U.S. We find that plant acquisition by an industry leader firm generates an increase in future sales-per-employee at the plant in subsequent periods. However, increased ownership concentration at both the national and state-level leads to a reduction in poultry processing worker wages, relative to the compensation for comparable jobs in other sectors. Relative to concentration and consolidation levels 25 years ago, these developments have led to between $37 and $710 million in additional revenues per year and between $27 and $218 million savings in the aggregate wage bill for the four largest poultry firms, implying a 2.6–12.0% increase in the gross labor margin for these firms.

Keywords: poultry industry, consolidation, employee productivity, wages
JEL Codes: L13, J43, Q13

1 Introduction

Ownership concentration in the meat processing industry in the United States has been a highly charged topic of discussion for nearly 100 years (Crespi and Saitone, 2018; Saitone et al., 2023*a*). Historically, the vast majority of concern surrounding this topic, and the resultant academic and policy inquiry, has focused upon how increased consolidation and concentration have the potential to i) allow meat processors to suppress prices paid to producers and/or ii) enable meatpackers to increase prices charged to wholesalers, retailers, and ultimately consumers.[1] During the COVID-19 pandemic, supply chain disruptions in meatpacking raised concerns about the relationship between concentration and food system resilience and set the stage for the U.S. meat processing industry to be the subject of policy and academic inquiry for the foreseeable future (Lusk, Tonsor and Schulz, 2021; Saitone et al., 2023*a*).

Recently, antitrust regulatory agencies— the Department of Justice and the U.S. Federal Trade Commission—have stated that labor-related impacts of mergers and heightened industry concentration are forms of antitrust harm that warrant increased scrutiny (Khan, 2021). Despite this emphasis, to date, there has not been a comprehensive investigation into how industry- or local- level concentration or consolidation impacts worker wages or worker productivity. In this paper, we seek to fill this void using plant-level sales per employee and merger/acquisition activity over time in the U.S. broiler chicken processing industry to estimate the impact that industry concentration has on employee remuneration and productivity from 1990 to 2019.

Outside of agriculture, there is a large and robust literature that documents a negative relationship between labor market concentration and wages (see Prager and Schmitt (2021) for a summary). This body of work has generally concluded that concentration in labor markets is a source of monopsony power, allowing employers to suppress wages be-

[1] Azzam and Anderson (1996); Ward (2002); Wohlgenant (2013) collectively provide an excellent summary of the extant literature in this area.

low marginal revenue product (Yeh, Macaluso and Hershbein, 2022).[2] The subset of this literature that focuses on how mergers/acquisitions affect wages is relatively small and has produced mixed empirical findings across a variety of industries.[3] This vein of literature has focused on the merging employer specifically (e.g., elimination of duplicate jobs, changes in management technology), rather than how the merger/acquisition impacted employer concentration. Prager and Schmitt (2021), the exception in this regard, found that consistent with merger-induced increases in labor market power reduced wage growth, particularly for workers whose skill sets are not transferable to another industry. We seek to contribute area of the literature by evaluating the effects of increased industry consolidation and concentration on economic outcomes for meatpacking workers over time.

We use plant-level data for all poultry processing facilities in the U.S. to investigate two components of the relationship between consolidation in the meat processing sector and economic outcomes for meatpacking workers.

1. First, we measure the effects of plant takeover by an industry leader firm on worker productivity (evaluated in terms of plant-level sales per employee) in that plant in future periods.

2. Second, we assess the effects of increased industry concentration (both at the national and state-level) on employee remuneration over time.

After estimating these two components of the industry concentration-labor relationship, we then use counterfactual simulation analysis to assess the extent to which consolidation has altered the sector wage bill and the gross labor margin over the past 25 years.

The U.S. broiler chicken processing industry provides a uniquely suited venue for this work. First, the broiler processing industry has experienced rising levels of ownership concentration over time. In 1963, the four-firm concentration ratio (CR4) for broiler processing

[2] Other potential reasons for this disparity include search frictions, preference heterogeneity, and policies such as non-compete and no-poaching agreements (Rinz, 2022).

[3] Prager and Schmitt (2021) provides a concise summary of the research in this area.

in the U.S. was 14% (MacDonald et al., 2000). The percentage increase experienced from 1980 to 2010 was 59%—CR4 of 32% in 1980 compared to a CR4 of 51% in 2010 (Crespi, Saitone and Sexton, 2012). Broiler processing experienced most of its increasing concentration in the 1980s and early 1990s. In 2021, the broiler industry CR4 was 52% (Saitone et al., 2023*a*). Second, in rural portions of the U.S., where labor markets are concentrated, and outside employment options for workers are spare, the potential impacts that mergers and acquisitions have on worker wages are likely significant (Posner, 2021). The geographically remote broiler processing locations provide a proving ground to test this assertion. Third, there have been accusations that the broiler industry is sufficiently concentrated that they are able to collude to suppress worker wages. For example, the Department of Justice (DOJ) filed a civil antitrust suit against three of the largest U.S. poultry producers who were alleged to have engaged in a conspiracy to share employee wage and benefit information in order to reduce worker compensation.[4]

Consistent with the extant literature from other industries, our results suggest that increased ownership concentration at both the national- and state-level leads to a reduction in poultry processing worker wages, relative to the compensation for comparable jobs in other sectors. According to our estimates, at current concentration levels, a 1% increase in state-level CR-2 concentration would generate a 0.8% reduction in poultry processing wages. Similarly, a 1% increase in national CR-2 concentration would reduce poultry processing wages by a similar magnitude.

These wage effects are in contrast to our findings regarding the worker productivity effects associated with plant acquisition. Our analysis suggests that plant acquisition by an industry leader firm generates an increase in future sales-per-employee at the plant in subsequent periods. In our baseline model, takeover by a top-4 firm increases sales-per-employee in the plant by approximately 18% in subsequent years. Taken together, our worker wage and productivity estimates suggest that progression toward a more concentrated ownership

[4]United States of America v. Cargill Meat Solutions Corp. et al. *Case 1:22-cv-01821-ELH*, available at https://www.justice.gov/opa/press-release/file/1521611/download.

structure in the industry over the last 25 years has led to $37 and $710 million in additional revenues per year and between $27 and $218 million savings in the aggregate wage bill for the four largest poultry firms, implying a 2.6–12.0% increase in the gross labor margin for these firms.

The remainder of this manuscript is organized as follows. In Section 2, we present a background on the evolution of concentration and labor in the U.S. meatpacking industry. Section 3 presents our analysis with respect to the effects of plant acquisition on worker productivity, and Section 4 presents our analysis of the effects of increased industry concentration on worker wages. In Section 5, we combine the results from these analyses to assess impacts on the wage bill and gross labor margins of the four largest poultry firms. Section 6 concludes with a discussion of implications for policymakers.

2 Background

During the 1960s the meatpacking industry (i.e., beef, pork, and poultry processing) began to move from large urban areas to small rural communities located throughout the Midwest and Southeastern parts of the U.S. (Whittaker, 2005).[5] The motivation for this move was twofold: i) co-location of processing and supply of animals for harvest would reduce transportation costs, and ii) lower labor costs by leaving urban labor unions and locating in "right-to-work" (i.e., where unions were weaker and non-unionized labor was available) states (Broadway and Stull, 2006). While meatpacking operations built in rural communities increased public revenue, provided business stimulus to other local businesses, and increased opportunities for low-skilled laborers (Leistritz and Sell, 2001), inadequate labor supplies in these locations provided processors with impetus to recruit workers from elsewhere.[6] Consensus suggests that the result has been an increasing reliance on immigrant workers who are not authorized

[5] Broiler production is geographically concentrated in the Southeastern portion of the United States.

[6] Saitone, Schaefer and Scheitrum (2021) provide a succinct summary of the challenges that the presence of a packing plant creates in host communities, including but not limited to increased tax burden of public assistance, health care, and schools.

for employment in the U.S. (Whittaker, 2005).

Today broiler production takes place in a fully vertically-integrated supply chain system. However, this wasn't always the case. In 1950, 95% of the broiler farms operated independently. By 1955, independent poultry operations only accounted for 10% of total broiler production. This once "traditional" market for broiler chickens has been replaced by growers working under production contracts for large broiler firms, now referred to as "integrators". Today, poultry firms are responsible for providing broiler chicks, and supplying feed, transportation, and veterinary services to contract growers who supply labor, land, and facilities (i.e., houses) to raise birds to maturity for harvest.[7] The broiler complex—consisting of the processing plant, feed mill, and further processing operations—is the center of the local industry with surrounding contract grower operations operating within 30 miles of the complex (Martinez, 1999).

Following the ownership consolidation of the 1950s, there was a shift from processors shipping whole birds to grocery stores (where butchers cut up and packaged chicken items) to processing plants supplying butchering (i.e., disassembling birds into parts) and value-added (e.g., nuggets) services before shipping to grocery stores and restaurants (Whittaker, 2005). This increased poultry processors' demand for dis-assembly line workers.[8] While labor is employed throughout the broiler production supply chain, processing plants are the most labor-intensive segment of the supply chain (Luckstead and Devadoss, 2021) and the focus of this paper.

The meatpacking industry in the U.S. has employed an ethnically diverse workforce including a large number of immigrants (Champlin and Hake, 2006). The immigration policies enacted during the 1980s and 1990s have helped provide the meatpacking industry

[7]Producers who are contracted to grow birds are compensated via tournament systems. Production contracts set specific requirements that ensure uniformity and quality standards for birds. The majority of contracts provide a base payment per pound and a bonus payment tied to the grower's relative performance benchmarked against other local growers (Vukina and Leegomonchai, 2006). The economic ramifications of these arrangements have been studied by researchers and are outside the scope of this paper.

[8]Despite extensive deskilling of dis-assembly line work, the inability to standardize the size and shape of animal carcasses has limited the ability to mechanize the process.

with a plentiful supply of labor (Champlin and Hake, 2006). During this same period, the remaining union strongholds seemed to dissipate. In 1980, 46% of workers in the meat products industry were union members; by 1987 union membership had declined to 21% (MacDonald et al., 2000). Immigrant workers, particularly those who are less skilled and lack education, are less able to exercise their rights and have substantially less bargaining power and ability to organize or unionize. In addition, high levels of employee turnover in the industry—80 to 100% per year— exacerbate workforce requirements and perpetuate aggressive recruitment of foreign-born unskilled labor (Champlin and Hake, 2006).

Declining worker unionization coincided with the increasing use of immigrant labor and declining wage rates.[9] For example, from 1980 to 2002, real average hourly wages fell from $10.30 to $6.46 in 1982 dollars (Champlin and Hake, 2006). The industrialization of meatpacking has increased the need for low-cost labor and foreign-born labor has typically filled this void, creating rural pockets of immigrants in towns dominated by meatpacking plants (Champlin and Hake, 2006). The ability to achieve higher rates of throughput to reduce processing costs depends on achieving management control over the pace of work on the factory floor (i.e., line speeds) and stifling labor demands for higher wages. During the 1990s and early 2000s, the workforce in most meatpacking plants became overwhelmingly Latino; this shift occurred despite the fact that the industry is geographically concentrated in states with historically low Latino populations (e.g., Arkansas, Georgia, Alabama) (Champlin and Hake, 2006).

3 Plant Acquisition and Employee Productivity

We use a difference-in-differences (DID) design to measure the effects of plant acquisition by an industry leader firm on worker productivity (evaluated in terms of plant-level sales per employee) in that plant in subsequent periods. To do so, we create a dataset that

[9] The exact number of unauthorized workers in meatpacking is unknown, but estimates range from 20% to 50% (Champlin and Hake, 2006).

includes annual plant-level information for all poultry processing facilities in the U.S. from the *National Establishment Time-Series* (NETS) database from 1990–2019. This dataset contains information on annual sales-per-worker employed at the plant, as well as the current owner of the plant.

Figure 1 summarizes the inherent relationships between firm size, employee productivity, and plant acquisition. Panel (a) of Figure 1 shows average employee productivity by firm rank over our sample period. As shown in the Figure, there is a strong relationship between the size of a broiler firm and the employee productivity (i.e., sales per employee) in its processing plants. Panel (b) of Figure 1 plots annual plant-level employee productivity for top-4 firms versus other firms between 1990–2019. The productivity divide has expanded over time. Panel (c) of Figure 1 shows the number of processing plants that change ownership each year. The majority of these changes in ownership correspond to acquisitions by large poultry firms. Taken together, the relationships in Figure 1 suggest that plant acquisition by an industry leader firm may have a meaningful impact on worker productivity in that plant in subsequent periods.

3.1 Methodology

Baseline Approach: For our baseline approach, we measure the impacts of plant takeover by an industry leader firm on worker productivity using a standard DID approach with two-way fixed effects (TWFE) (Callaway and Sant'Anna, 2021). Our specification is as follows:

$$EP_{it} = \alpha + \beta \text{MATop-N}_{it} + \gamma_i + \delta_t + \epsilon_{it} \tag{1}$$

where dependent variable EP_{it} in equation (1) represents the sales per employee (specified in natural logarithmic form) in plant i observed in year t. Treatment variable MATop-N_{it} is a dummy variable that equals one for a given plant i that is acquired by a top-N firm (i.e., an industry leader firm) in the year the plant is acquired and for all subsequent years. This

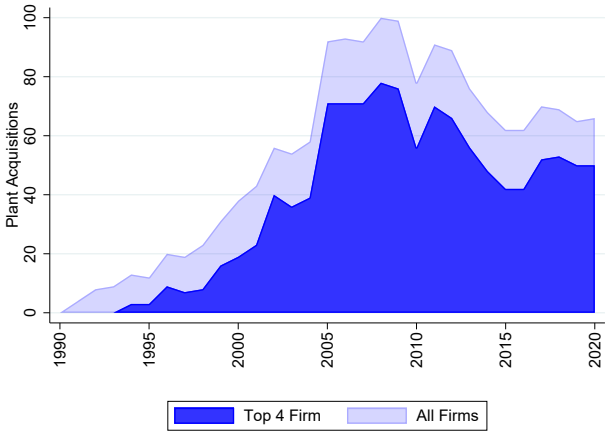
Figure 1: Firm Size, Employee Productivity, and Plant Acquisitions



(a) Employee Productivity by Firm Rank



(b) Employee Productivity over Time



(c) Acquisitions over time

Notes: Data underlying this Figure include annual plant-level information for all poultry processing facilities in the U.S. from 1990–2019 obtained from the *National Establishment Time-Series* (NETS) database.

variable is equal to zero in periods prior to acquisition for plants that experience a change in ownership. The variable is also equal to zero in all periods for all plants that never experience a change in ownership. We consider specifications where an "industry leader firm" is defined, alternatively, as a "top-2" firm, a "top-3" firm, a "top-4" firm, . . . , or a "top-10" firm in the year the acquisition occurs.

Variables γ_i and δ_t denote the TWFE. Variable γ_i is the plant-specific fixed effect, which controls for time-invariant characteristics of a given plant. Variable δ_t is the time fixed effect, which controls for time-variant market-level input and output price changes and other supply- and demand-side shocks that are common to all plants in a given period.

Accounting for Other Acquisitions: It is possible that a change in plant ownership generates a change in employee productivity in the plant regardless of whether or not the purchasing firm is a "top" firm. If so, specification (1) may suffer from omitted variable bias by not accounting for changes in ownership that do not lead to industry consolidation. We also consider the following specification to account for this:

$$EP_{it} = \alpha + \beta_0 \text{MA}_{it} + \beta_1 \text{MATop-N}_{it} + \gamma_i + \delta_t + \epsilon_{it} \tag{2}$$

where variable MA_{it} is a dummy variable synonymous with treatment variable $MATop\text{-}N_{it}$ from equation (1), except that it takes value one for any plant acquisition (regardless of whether the acquiring firm is an industry leader). All other variables are defined as in equation (2).

Because equation (2) includes both variables MA_{it} (which measures the impact of plant acquisition) and MATop-N_{it} (which now measures the incremental effect of acquisition by a top-N firm above and beyond the general impact of plant acquisition) the treatment effect is additive. In other words, the productivity impact of acquisition by a top-N firm as specified in equation (2) is $\beta_0 + \beta_1$.

Analyzing Treatment Dynamics: Parallel pre-treatment trends between acquired plants

relative to non-acquired and not-yet-acquired plants is a necessary condition for causal interpretation of estimated treatment effects in our DiD design. While one cannot test for these parallel trends directly, analysis of outcome trends in the pre-treatment period can be informative about the validity of this assumption (Freyaldenhoven, Hansen and Shapiro, 2019). Further, the full impacts of plant acquisition have the potential to compound for several years. Accordingly, to investigate pre-treatment trends and evaluate treatment dynamics, I employ the DiD-with-multiple-periods estimator proposed by (Callaway and Sant'Anna, 2021):

$$EP_{it} = \gamma_i + \delta_t + \sum_{e=-k}^{-1} \delta_e^{anticip} \text{MATop-N}_{it}^e + \sum_{e=0}^{L} \beta_e \text{MATop-N}_{it}^e + v_{it} \tag{3}$$

where variable MATop-N_{it}^e is akin to treatmnet variable MATop-N_{it} in equation (1), except that it is observed e periods away from the initial acquisition date. Parameters β_e measure the effect of the regulatory change on the "treated" plant over time.

The model tests the pre-treatment parallel trends assumption through the inclusion of the terms $\sum_{e=-k}^{-1} \text{MATop-N}_{it}^e$. These variables take value one in the periods preceding acquisition. A finding that corresponding coefficients $\delta_e^{anticip}$ are not trending presents strong evidence that the pre-treatment parallel trends assumption holds.

Summary Statistics: Our analyses include 7,373 observations for 477 individual plants and 302 firms. The average plant generated $192,925 in sales per employee (minimum: $3,112, maximum: $9,450,026). Over the period of analysis, we observe a total of 271 acquisition events where the acquiring firm was a top-4 firm.

3.2 Results

Figure reports treatment effects of plant acquisition by a top-N firm on sales-per-employee in the acquired plant (and 95% confidence intervals), obtained by estimating equation (1) in panel (a),[10] equation (2) in panel (b),[11] and equation (3) in panel (c). In panel (a) the

[10] Appendix Table A1 shows the complete regression output for this analysis.
[11] Appendix Table A2 shows the complete regression output for this analysis.

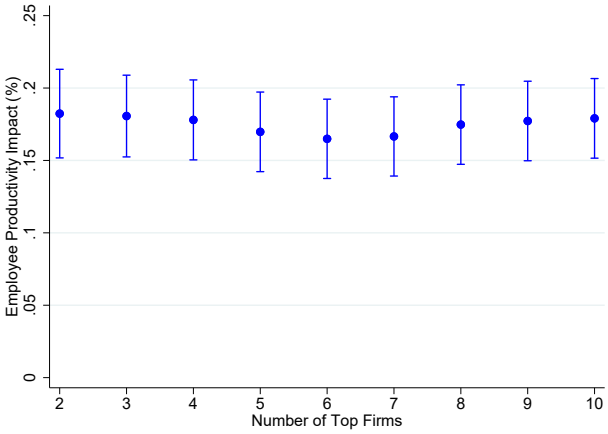
reported treatment effect is $\hat{\beta}$. In panel (b), the reported treatment effect is $\hat{\beta}_0 + \hat{\beta}_1$. The "other acquisition" estimate in panel (b) corresponds to $\hat{\beta}_0$ in equation (2). In panel (c), pre- and post-treatment effects correspond to $\hat{\delta}_e^{anticip}$ and $\hat{\beta}_e$.

Referring first to the coefficient estimates in panel (a) of Figure 2, we see that plant acquisition by an industry leader firm generates an increase in future sales-per-employee at the plant in subsequent periods. This result is statistically significant at the 1% level for all constructions of the "industry leader" firm from a top-2 firm to a top-10 firm. The magnitude of the coefficient point estimate suggests the relationship is also *economically* significant. Our results suggest that takeover by a top-2 firm generates a 18.2±3.1% increase in sales-per-employee at the acquired plant in future years.[12] Impact estimates are surprisingly stable across all constructions of the industry leader firm. When variable MATop-N_{it} is defined to take value 1 for all top-4 firms, our results suggest that plant acquisition increases sales-per-employee in the plant by approximately 17.8±2.7%. When the industry leader firm is defined to be a top-10 firm, the impact estimate is 17.9±2.7%.

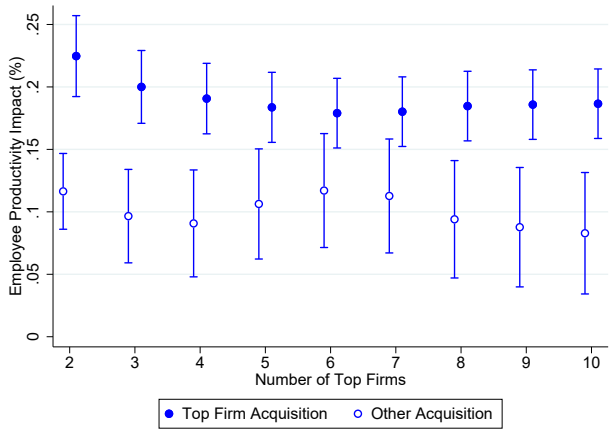
Turning to panel (b) of Figure 2 with the results generated from estimating equation (2), we see that acquisition by any firm (whether an industry leader or not) generates an increase in sales-per-employee. However, this effect is substantially larger in magnitude when the acquiring firm is an industry leader. As with the baseline results, our point estimates are statistically significant at the 1% level for both $\hat{\beta}_0$—the effect of plant acquisition by any firm (whether an industry leader or not)—and $\hat{\beta}_1$—the incremental effect when the acquiring firm is an industry leader. In this specification, the impact of acquisition by a non-top firm appears reasonably stable across the various constructions of variable MATop-N_{it}. When construction MATop-2_{it} is used, acquisition by a non-top-2 firm increases sales per employee by 11.6±3.0%. For the top-4 firm construction, acquisition by a non-top-4 firm increases sales per employee by 9.1±4.3%. For the top-10 firm construction, acquisition by a non-top

[12]Note that—in this sentence—the number 18.2 denotes the point estimate of the estimated impact and the number ±3.1 denotes the 95% confidence interval. This convention is used throughout the remainder of the manuscript.

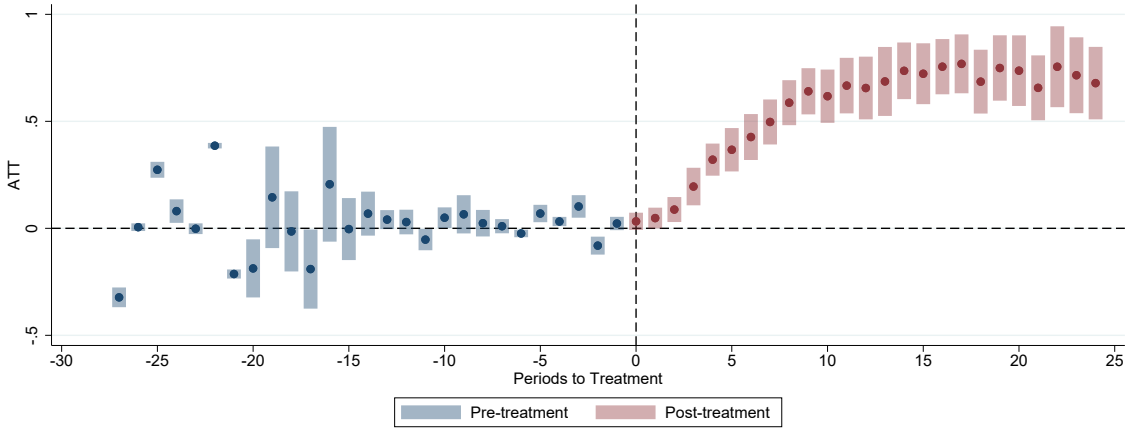
Figure 2: Impacts of Plant Acquisition on Employee Productivity



(a) Baseline Approach



(b) Accounting for Other Acquisitions



(c) Analyzing Treatment Dynamics

Notes: Figure reports treatment effects of plant acquisition by a top-N firm on sales-per-employee in the acquired plant (and 95% confidence intervals), obtained by estimating equation (1) in panel (a), equation (2) in panel (b), and equation (3) in panel (c). In panel (a) the reported treatment effect is $\hat{\beta}$. In panel (b), the reported treatment effect is $\hat{\beta}_0 + \hat{\beta}_1$. The "other acquisition" estimate in panel (b) corresponds to $\hat{\beta}_0$ in equation (2). In panel (c), pre- and post-treatment effects correspond to $\hat{\delta}_e^{anticip}$ and $\hat{\beta}_e$ from equation (3).

firm increases sales per employee by 8.29±4.9%.

However, in contrast to the results in panel (a), the magnitude of the effect appears largest when our definition of MATop-N_{it} includes only a handful of firms and declines as the number of firms included in MATop-N_{it} grows. We note that this outcome is consistent with the relationship shown in panel (a) of Figure 1 that the largest firms experience the highest sales-per-employee and that sales-per-employee generally fall as the size of the firm shrinks. We estimate that acquisition by a top-2 firm increases sales per employee by 22.5±3.2%. When the regression is defined to examine acquisition by a top-4 firm and a top-10 firm respectively, the impact falls to 19.1±2.8% and 18.7±2.8%.

Finally, referring to the results of the treatment dynamics analysis in panel (c) of Figure 2, we find no evidence of significant pre-trends. These pre-treatment results present strong evidence that our coefficients can be interpreted causally. Further, looking at the post-treatment effects, we see that the impacts of plant acquisition are not fully realized for several years following initial acquisition.

4 Industry Concentration and Worker Wages

After investigating the impacts of increased consolidation on employee productivity at the plant level in Section 3, we now estimate the effects of increased concentration—at both the state and national level— on the evolution of poultry processing plant worker wages. The identification strategy for our baseline approach here is closely related to the relative-price-of-a-substitute (RPS) method (Beeler et al., 2023; Carter and Smith, 2007; McKendree, Saitone and Schaefer, 2021). We investigate the extent to which changes in industry concentration in the poultry processing sector affect the wages for poultry processing workers, relative to comparable wages for workers in other industries.

Economic Intuition: Our logic here is as follows. Because poultry workers and non-poultry workers exhibit relatively comparable skill levels, we expect the wages to move

together over the medium- to long-run. Further, short-run macroeconomic shocks should affect both wages in a similar way. We believe changes in ownership concentration in the poultry sector may affect the poultry-to-non-poultry wage differential in at least two ways. First, because a large share of employees in these processing plants are migrant workers, there may be meaningful short-run labor frictions. For example, if a worker found work at a processing plant through her informal migrant community network, the worker may be unable (either due to language barriers or other informational impediments) to learn their earning potential outside the plant. She may fear reprisal to other employees within the same migrant community network as a result of her decision to leave to seek a higher outside. wage In the most extreme example, the worker may even be legally ineligible for work outside the plant.

Additionally or alternatively, changes in concentration levels may affect the poultry-to-non-poultry-worker wage differential—not as a result of labor suppression—but as a result of labor-saving capital investment. As discussed in Section 2, in recent years, many broiler plants have adopted automation technology, at various stages of processing. To the extent that consolidation is a systematic driver of these investments and automation makes poultry processing less labor intensive or requires lower-skilled workers, one would expect the poultry wage to fall relative to the non-poultry wage as a result of increased concentration.

Data: To test these hypotheses, we obtain data on the average weekly wage for poultry processing workers (i.e., private code 311615 from the North American Industry Classification System (NAICS)) from the U.S. Bureau of Labor Statistics Quarterly Census of Employment and Wages (QCEW) for 18 states for which we have a complete time series of poultry processor worker wages.[13] QCEW average weekly wages are derived by dividing quarterly total wages by average monthly employment levels and dividing the result by 13, for the 13 weeks in the quarter. The earliest available date for the poultry processing wages from

[13]These states are Alabama, Arkansas, Georgia, Iowa, Illinois, Indiana, Kentucky, Louisiana, Minnesota, Missouri, Mississippi, North Carolina, New York, Ohio, Pennsylvania, South Carolina, Tennessee, Texas, and Virginia.

QCEW is 1997. Thus, for this analysis, our sample period runs from 1997–2019.

Alongside poultry worker wages, we collect two alternative sets of "comparable" wages for workers in other industries. First, from the Federal Reserve Economic Data (FRED), we collect the national, average weekly earnings for production and non-supervisory workers from other (non-poultry-processing-related) industries. Second, we collect average weekly earnings for workers in the construction industry (i.e., NAICS code 1012) for the 18 states for which we have poultry worker wages. The construction wage is chosen because it is the industry with the largest share of immigrant workers in the U.S. (USA Facts, 2023). There are pros and cons to both these datasets. The FRED production wage data is representative of a larger set of comparable industries, but is available only at the national level. The construction wage may not be as representative of the complete set of outside options, but may be more reflective of state-specific wage trends.

Additionally, we use the NETS data described in Section 3 to construct annual ownership concentration ratios for the poultry processing industry at both the national and the state level. Appendix Figure A1 shows the distribution of these constructed concentration ratios for CR-2 to CR-20. As shown in Figure, A1, the national concentration ratios exhibit an ample degree of variation over a range of CR measures. However, for the state-level concentration measures, many states have CR measures close to 1 even when few firms are considered in the analysis. When more firms are considered (e.g., CR-7 and beyond), effectively 100% of observations include state-level concentration ratios at or near 1. The consequence of this substantial concentration at the state level is that—for CR measures that include more than a handful of firms—the data may not include sufficient variation in the explanatory variables to adequately identify the effects of state-level concentration on worker wages. Accordingly, for this empirical analysis, we consider the range of concentration ratios CR-2 to CR-10 at the national level and CR-2 to CR-5 at the state level.

4.1 Methodology

To assess the effects of increased national and state-level ownership concentration on poultry processing plant worker wages, we estimate the following baseline model:

$$w_{st} = \alpha + \beta_0 v_t + \beta_1 \text{CR-N}_t^{US} + \beta_2 \text{CR-N}_{st}^{State} + \lambda_s + \epsilon_{st} \tag{4}$$

where dependent variable w_{st} is the log-transformed average weekly wage for poultry processing workers in state s in year t. Right-hand side variable v_{st} is alternatively defined as the log-transformed composite average weekly earnings for other industries (i.e., the composite wage model), or the log-transformed average weekly earnings for construction workers (i.e., the construction wage model). We include state-fixed effects λ_s, which allow the average differential between poultry and non-poultry worker wages to vary across states.

Our explanatory variables of interest CR-N_t^{US} and CR-N_{st}^{State} correspond to the national and state-level concentration ratios, respectively, for the top "N" firms as observed at time t. These variables test whether changes in the differential between poultry and non-poultry worker wages are correlated with the rise or fall of ownership concentration at both the national and state level. We estimate specifications that include all combinations of national concentration ratios CR-2^{US} to CR-10^{US} and state-level concentration ratios CR-2^{State} to CR-5^{State}.

Model Robustness: We believe the identification strategy employed in equation (4) provides a sound estimate of the relationship between national and state-level ownership concentration and poultry processing plant worker wages. However, we are unable to rule out the possibility of omitted variable bias. In other words, there is a possibility that factors not included in the model could be simultaneously influencing both concentration in the poultry sector and the differential between poultry and non-poultry worker wages. If so, parameters β_1 and β_2 in equation (4) may be biased estimates of the true effect of industry concentration on wages.

In an effort to reduce the possibility of omitted variable bias, we also re-estimate the model using the following TWFE specification:

$$w_{st} = \alpha + \beta_2 \text{CR-N}_{st}^{State} + \lambda_s + \zeta_t + \epsilon_{st} \tag{5}$$

where variable ζ_t is a time-fixed effect, and all other variables are defined as in equation (4). While the inclusion of the year fixed effect does not allow for identification of the impacts of national concentration, it does provide a dependable estimate of the relationship between state-level changes in concentration and poultry worker wages. As above, we estimate specifications that, alternatively, include state-level concentration ratios CR-2^{State} to CR-5^{State}.

Summary Statistics: Table 1 reports the summary statistics for this analysis. Our dataset includes 432 observations (i.e., 18 states × 24 years). The average state-level poultry worker wage was $540 per week (std. dev. $122), the average composite non-poultry worker wage was $612 per week (std. dev. $113), and the average construction worker wage was $870 per week (std. dev. $214). By design, national and state-level CR values increase as more firms are included in the analysis. On average, over our sample period, the national CR-4 was 0.68. As explained above, individual states are much more concentrated than the nation as a whole. The average state-level CR-4 over the period of analysis was 0.98 and ranges from 0.64 to 1.00.

4.2 Results

Baseline Model Results: Figure 3 reports the effects of increased national and state-level ownership concentration on poultry processing plant worker wages, according to the composite wage model and the construction wage model. These results correspond to specifications of equation (4) that include all combinations of national concentration ratios CR-2^{US} to CR-10^{US} and state-level concentration ratios CR-2^{State} to CR-5^{State}. Appendix Figure A2

Table 1: Summary Statistics (n = 432)

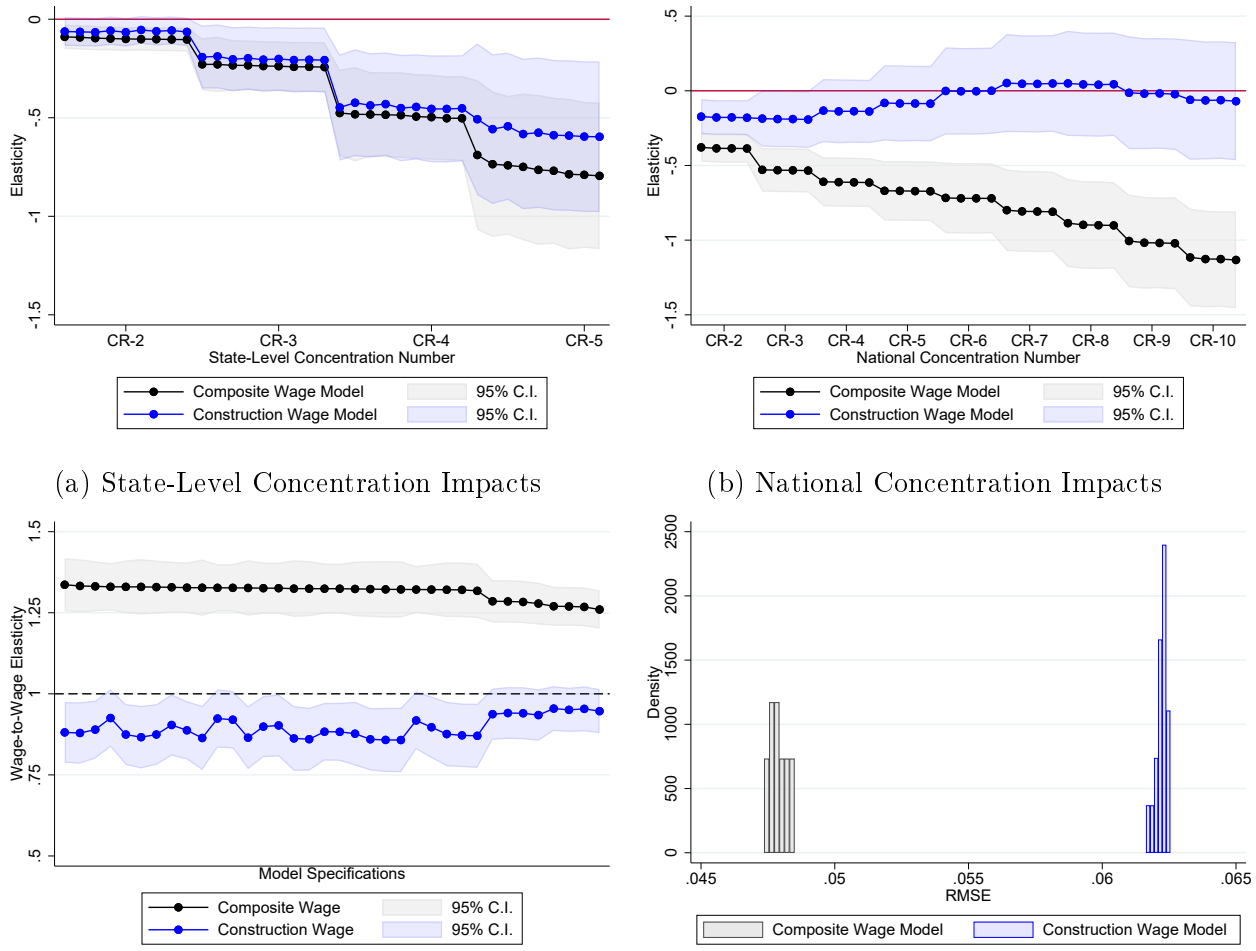
Variable	Mean	Std. Dev.	Min	Max
Wage Variables				
Poultry Worker Wage	$540	$122	$316	$963
Non-Poultry Worker Wage	$612	$113	$431	$838
Construction Worker Wage	$870	$214	$467	$1,504
National Concentration				
CR-2	0.52	0.11	0.34	0.64
CR-3	0.62	0.08	0.44	0.71
CR-4	0.68	0.09	0.50	0.78
CR-5	0.72	0.08	0.55	0.81
CR-6	0.75	0.07	0.59	0.83
CR-7	0.78	0.06	0.63	0.86
CR-8	0.80	0.06	0.67	0.87
CR-9	0.82	0.05	0.70	0.89
CR-10	0.84	0.05	0.74	0.90
State-Level Concentration				
CR-2	0.88	0.13	0.48	1.00
CR-3	0.95	0.07	0.64	1.00
CR-4	0.98	0.04	0.74	1.00
CR-5	0.99	0.02	0.82	1.00

reports these results on a combination-by-combination basis for all national and state-level concentration ratios.

For diagnostic purposes, we first refer briefly to the performance of our control wages in panel (c) of Figure 3 and to the distributions of root mean squared errors (RMSEs) in panel (d). Panel (c) shows the estimated poultry-worker-wage-to-non-poultry-worker-wage elasticity (i.e., $\hat{\beta}_0$ from equation (4)) for both the composite wage model and the construction wage model. These results suggest that both the composite wage and the construction wage move closely with the poultry worker wage, supporting our identification strategy. The RMSE distributions in panel (d) also suggest that both the composite wage model and the construction wage model perform well. Comparing between the RMSE distributions, it appears the composite wage model fits the data slightly better than the construction wage model.

Turning to our variables of interest, panel (a) of Figure 3 reports the effects of state-

Figure 3: Effects of Increased Concentration on Poultry Worker Wages—Alternative Design



(a) State-Level Concentration Impacts

(b) National Concentration Impacts

(c) Wage-to-Wage Elasticities

(d) Model Performance

Notes: Figure reports the effects of increased national and state-level ownership concentration on poultry processing plant worker wages, according to the composite wage model and the construction wage model. These results correspond to specifications of equation (4) that include all combinations of national concentration ratios CR-2^{US} to CR-10^{US} and state-level concentration ratios CR-2^{State} to CR-5^{State}. Panel (a) of the Figure reports the effects of state-level concentration and panel (b) reports the effects of national concentration. Panel (c) shows the estimated poultry-worker-wage-to-non-poultry-worker-wage elasticity across these specifications, and panel (d) reports the distribution of the root mean squared error (RMSE) from all specifications to gauge model performance.

level concentration on poultry worker wages across the two model specifications. In both the composite wage model and the construction wage model, these coefficient estimates are negative and statistically significant at the 1% level in all specifications, suggesting that an increase in state-level concentration has a negative effect on poultry processing wages. Point estimates are highly consistent across the two models. In the composite wage model, point estimates range in magnitude from -0.80±0.37 (in the CR-5^{US}; CR-2^{State} specification) to -0.09±0.06 (in the CR-2^{US}; CR-5^{State} specification).

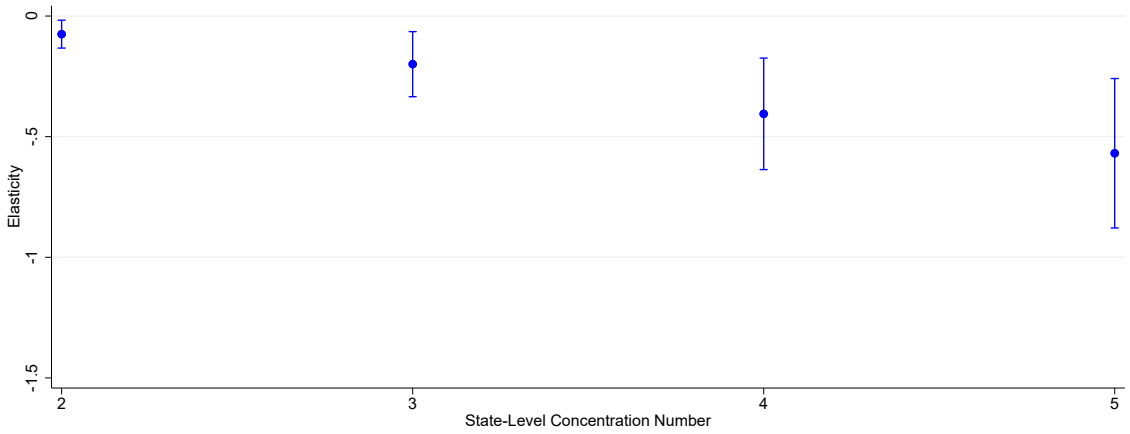
Panel (b) of Figure 3 reports the effects of national concentration on poultry worker wages across the two model specifications. In this chart, we see that findings differ based on the choice of the non-poultry-worker wage. In the composite wage model, all coefficient estimates are negative and statistically significant at the 1% level. Thus, the findings from the composite wage model suggest that—even beyond the effects of increased concentration at the state level, increased concentration at the national level can affect poultry worker wage outcomes. Point estimates range in magnitude from -1.13±0.32 (in the CR-2^{US}; CR-4^{State} specification) to -0.38±0.10 (in the CR-10^{US}; CR-2^{State} specification).

However, national concentration results differ slightly for the construction wage model. For national CR-2 and CR-3 measures, we continue to observe a negative and statistically significant relationship between national concentration levels and poultry worker wages, though this effect is slightly smaller in magnitude than for the composite wage model. However, in the construction wage model, we do not observe a statistically meaningful relationship between national concentration and poultry worker wages for changes in concentration measures beyond CR-3.

TWFE Robustness Results: Results in Figure 4, which report the effects of increased state-level ownership concentration on poultry processing plant worker wages as estimated via the TWFE specification are largely consistent with those from our baseline specification. Appendix Table A3 shows the complete regression output for this analysis. All coefficient estimates are negative and statistically significant (though only at the 5% threshold for CR-

2) and of a similar magnitude (ranging from -0.57±0.31 to -0.08±0.06) to those in panel (b) of Figure 3.

Figure 4: State-Level Concentration TWFE Impacts



Notes: Figure reports the effects of increased state-level ownership concentration on poultry processing plant worker wages as estimated via the TWFE specification shown in equation (5).

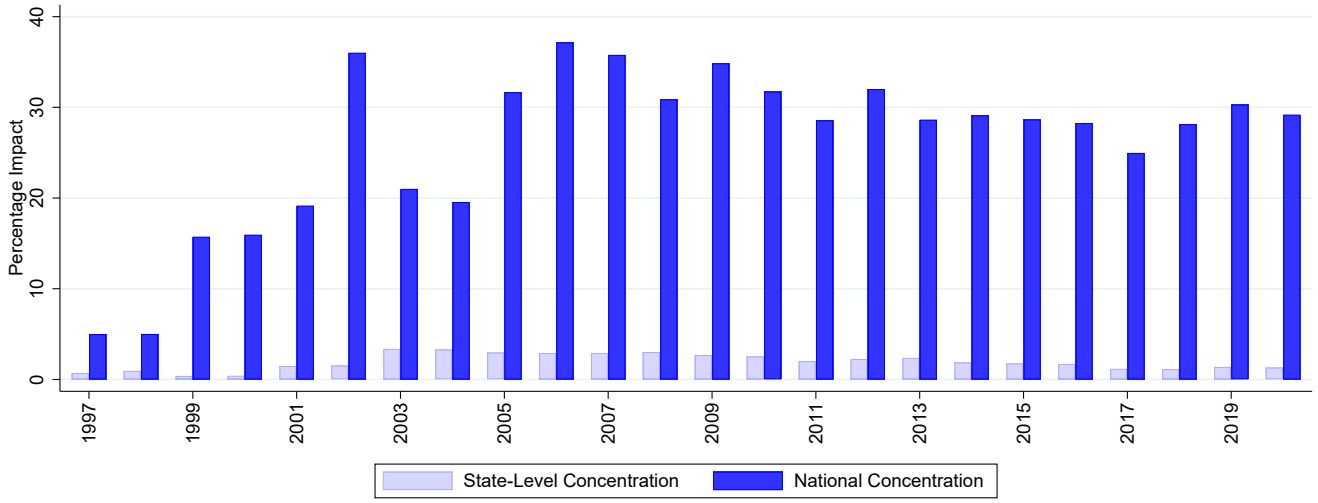
5 Concentration, Consolidation, and Top-4 Firm Sales and Wage Bill

In this section, we conduct a counterfactual simulation analysis to assess the extent to which consolidation has altered the aggregate wage bill and the gross labor margin for the four largest poultry firms over the past 25 years. To do so, we first determine how national and state-level CR-4 measures in the U.S. poultry industry would have evolved over the past 25 years had plant-level consolidation not occurred. We then use our estimation results from Section 3 and Section 4 to obtain counterfactual estimates of firm-level sales and worker wages based on these hypothetical CR-4 measures.

5.1 Methodology

Generating Counterfactual National and State-level CR-4 Measures: We construct our counterfactual national and state-level CR-4 measures (denoted $\widetilde{\text{CR-4}}_t^{US}$ and $\widetilde{\text{CR-4}}_{st}^{State}$, respectively) using a method consistent with Saitone et al. (2023*b*). The "no consolidation" CR-4 in a given year t is evaluated by assigning the sales of all plants operating in that year to the plants' initial owners, as observed in the NETS data over our 25-year sample. Figure 5 reports the impact of consolidation on the national CR-4 (evaluated as a percentage change relative to the "no consolidation" counterfactual CR-4) and the average impact on the state-level CR-4 for the 18 states in our sample. Based on this analysis, we find that—as of 2020—consolidation has increased the national CR-4 by approximately 30% and the state-level CR-4 by approximately 2% for the average state in our sample.

Figure 5: Consolidation and National and State-level CR-4 Measures



Notes: Figure reports the impact of consolidation on the national CR-4 (evaluated as a percentage change relative to the "no consolidation" counterfactual CR-4) and the average impact on the state-level CR-4 for the 18 states in our sample.

Accounting for Changes in Employee Productivity: Of course, as shown in Section 3, consolidation also constributed to increased concentration by increasing the sales-per-employee in the acquired plants. Using the estimated relationship between consolidation

and employee productivity from equation (1), we account for these consolidation-induced changes in plant-level sales by making the following adjustment to the observed sales data:

$$Sales_{it}^{CF} = EP_{it} \times (1 - \beta) \times \text{MATop-4}_{it} \times \text{Emp}_{it} \tag{6}$$

where variable Emp_{it} denotes the number of employees in plant i at time t and all other variables are as defined in equation (1).

Generating Counterfactual Wages and Wage Bill: Using the estimated relationship between concentration and worker wages described in Section 4, we derive counterfactual wages (w_{st}^{CF}) in the no-consolidation scenario as:

$$w_{st}^{CF} = w_{st} + \beta_1(\widetilde{\text{CR-4}}_t^{US} - \text{CR-4}_t^{US}) + \beta_2(\widetilde{\text{CR-4}}_{st}^{State} - \text{CR-4}_{st}^{State}) \tag{7}$$

where variables $\widetilde{\text{CR-4}}_t^{US}$ and $\widetilde{\text{CR-4}}_{st}^{State}$ are the counterfactual CR-4 measures described above and all other variables are as defined in equation (4). Accordingly, the actual and counterfactual aggregate wage bills for the top-4 firms are $\sum_i w_{st} \times \text{Emp}_{it}$ and $\sum_i w_{st}^{CF} \times \text{Emp}_{it}$ for all plants i belonging to top-4 firms.

Alternative Model Specifications: Finally, we assess the sensitivity of these results by repeating this simulation where counterfactual wage estimates are alternatively generated using coefficients from the construction wage model and the TWFE wage model in addition to the composite wage model (i.e., our baseline specification). For each of these specifications, we derive confidence intervals around our estimates using a Bayesian bootstrap approach with 1,000 resampled draws from the posterior distributions of each coefficient in equations (6) and (7).

5.2 Results

Panels (a) and (b) of Figure 6 show the estimated effects of consolidation on aggregate revenues (panel a) and wage bill (panel b) for the four largest poultry firms over the past 25

years. According to our counterfactual analysis, consolidation has led to $493 million (95% Confidence Interval: $37 to $710 million) in additional revenues per year and $170 million (95% Confidence Interval: $27 to $218 million) savings in the aggregate wage bill for the four largest poultry firms as of 2020. Based on these results, panel (c) of Figure 6 shows the implied effects of consolidation on the gross labor margin (defined as aggregate sales minus the wage bill) for the top-4 firms. According to our baseline approach, the additional revenues and labor savings generated by these developments imply a 9% (95% Confidence Interval: 2.6% to 12.02%) increase in the gross labor margin for these firms.

Finally, panel (d) repeats this analysis alternatively using counterfactual wage estimates generated by the construction wage model and the TWFE wage model. These alternative approaches generate implied impacts on the gross labor margin of 7.1% and 6.6%, respectively. We also note that the TWFE wage model almost certainly under-estimates these impacts because—as explained in Section 4.1—the estimation strategy allows only for the identification of the state-level concentration effect. Thus, the TWFE simulation does not incorporate the effects of changes in national concentration levels that extend beyond changes at the state level.

6 Conclusion

The current sentiment among the leadership of both agencies in the U.S. responsible for antitrust enforcement (DOJ and Federal Trade Commission) is that labor-related impacts of mergers and heightened industry concentration are forms of antitrust harm that warrant increased scrutiny (Khan, 2021). Our analysis sheds light on this sentiment in the context of the U.S. poultry processing industry. We use plant-level data for all poultry processing facilities in the U.S. to investigate two components of the relationship between consolidation in the meat processing sector and economic outcomes for meatpacking workers. First, we measure the effects of plant takeover by an industry leader firm on worker productivity

Figure 6: Impacts of Consolidation on Top-4 Firm Sales and Wage Bill



(a) Evolution of Top-4 Sales

(b) Evolution of Top-4 Wage Bill

(c) Evolution of Top-4 Gross Labor Margin

(d) Alternative Model Specifications

Notes: Panels (a) and (b) of the Figure show the estimated effects of consolidation on aggregate revenues (panel a) and wage bill (panel b) for the four largest poultry firms over the past 25 years. Based on these results, panel (c) shows the implied effects of consolidation on the gross labor margin (defined as aggregate sales minus the wage bill) for the top-4 firms. Panel (d) repeats this analysis alternatively using counterfactual wage estimates generated by the construction wage model and the TWFE wage model in addition to the composite wage model (i.e., our baseline specification). For each of these specifications, we derive confidence intervals around our estimates using a Bayesian bootstrap approach with 1,000 resampled draws from the posterior distributions of each coefficient in equations (6) and (7).

(evaluated in terms of plant-level sales per employee) in that plant in future periods. Second, we assess the effects of increased industry concentration (both at the national and state-level) on employee remuneration over time. After estimating these two components of the industry concentration-labor relationship, we then use counterfactual simulation analysis to assess the extent to which consolidation has altered the sector wage bill and the gross labor margin over the past 25 years.

We find that plant acquisition by an industry leader firm generates an increase in future sales-per-employee at the plant in subsequent periods. However, increased ownership concentration at both the national and state-level leads to a reduction in poultry processing worker wages, relative to the compensation for comparable jobs in other sectors. Relative to concentration and consolidation levels 25 years ago, these developments have led to $37 and $710 million in additional revenues per year and between $27 and $218 million savings in the aggregate wage bill for the four largest poultry firms, implying a 2.6–12.0% increase in the gross labor margin for these firms.

Historically, U.S. anti-trust policy has focused on how concentration in an industry affects consumer prices. Our results suggest that further attention is needed to understanding the relationship between concentration and its economic impacts on workers. Additionally, it is important to recognize the observed changes in productivity and wages due to changes in concentration have impacts on the economic situation of the workers and the local economies in which they are located. These impacts too have federal, state, and even local policy relevance.

Finally, while we have a strong identification strategy to estimate the effect of concentration on wages, we stress that further research is needed to understand the specific mechanisms underlying this relationship. As with any research, we cannot fully rule out the possibility of omitted variable bias. For example, our analysis is conducted at the national and state level. In many contexts, labor market wages may be determined on a more localized basis.

Conflicts of Interest: The authors report no conflicting interests relevant to 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 represent any official U.S. Department of Agriculture or U.S. government determination or policy.

Funding Source: This work was funded as part of USDA Cooperative Agreement 58-0111-21-022.

Ethics Committee Approval: This project did not involve human subjects research.

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A Supplementary Tables and Figures

Table A1: Impacts of Plant Acquisition on Employee Productivity—Baseline Results

	(1) Top-2	(2) Top-3	(3) Top-4	(4) Top-5	(5) Top-6	(6) Top-7	(7) Top-8	(8) Top-9	(9) Top-10
MATop-N$_{it}$	0.18***	0.18***	0.18***	0.17***	0.17***	0.17***	0.18***	0.18***	0.18***
	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Constant	11.78***	11.77***	11.77***	11.77***	11.77***	11.77***	11.77***	11.77***	11.77***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Group FX	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FX	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Obs	7,373	7,373	7,373	7,373	7,373	7,373	7,373	7,373	7,373
R^2	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87

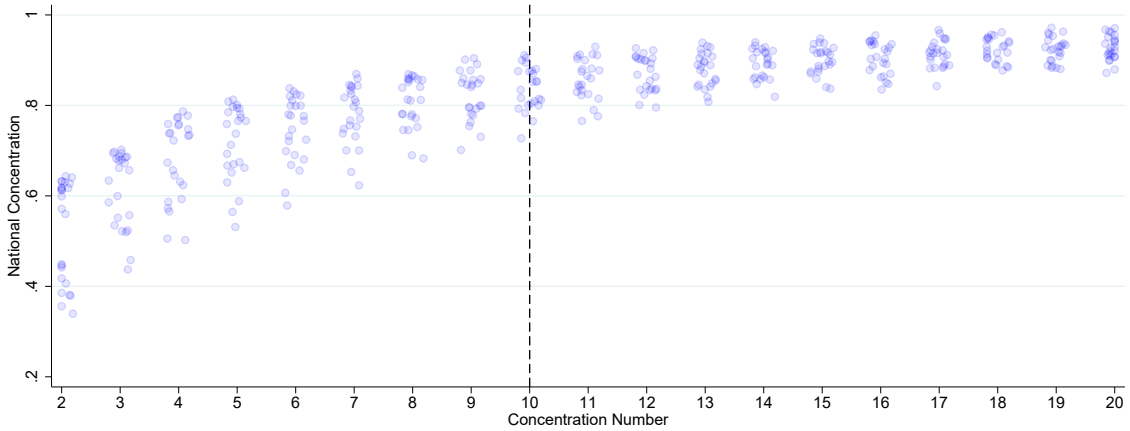
Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table A2: Plant Acquisition and Employee Productivity—Accounting for Other Acquisitions

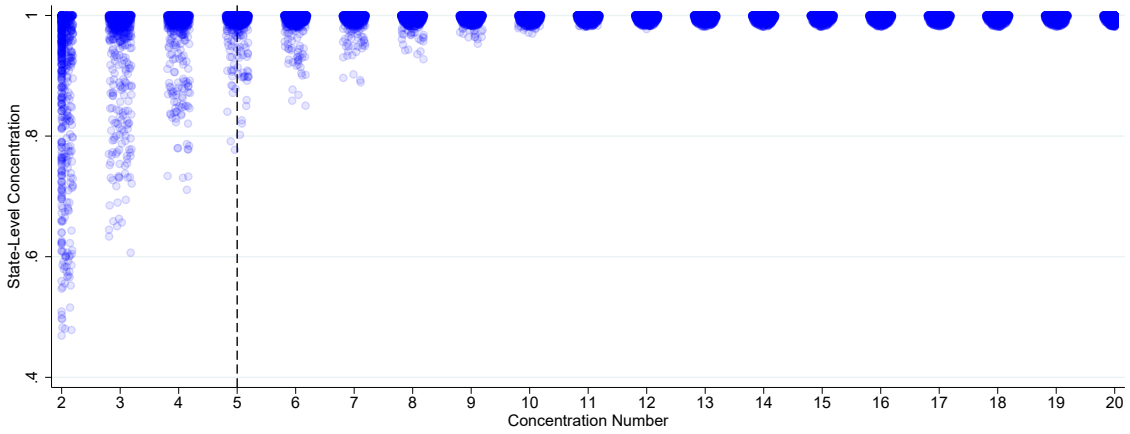
	(1) Top-2	(2) Top-3	(3) Top-4	(4) Top-5	(5) Top-6	(6) Top-7	(7) Top-8	(8) Top-9	(9) Top-10
MA$_{it}$	0.12***	0.10***	0.09***	0.11***	0.12***	0.11***	0.09***	0.09***	0.08***
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
MATop-N$_{it}$	0.11***	0.10***	0.10***	0.08***	0.06**	0.07***	0.09***	0.10***	0.10***
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.03)	(0.03)	(0.03)
Constant	11.76***	11.76***	11.76***	11.76***	11.76***	11.76***	11.76***	11.76***	11.76***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Group FX	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FX	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Obs	7,373	7,373	7,373	7,373	7,373	7,373	7,373	7,373	7,373
R^2	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87

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

Figure A1: Distribution of Concentration Ratios, National and State-Level



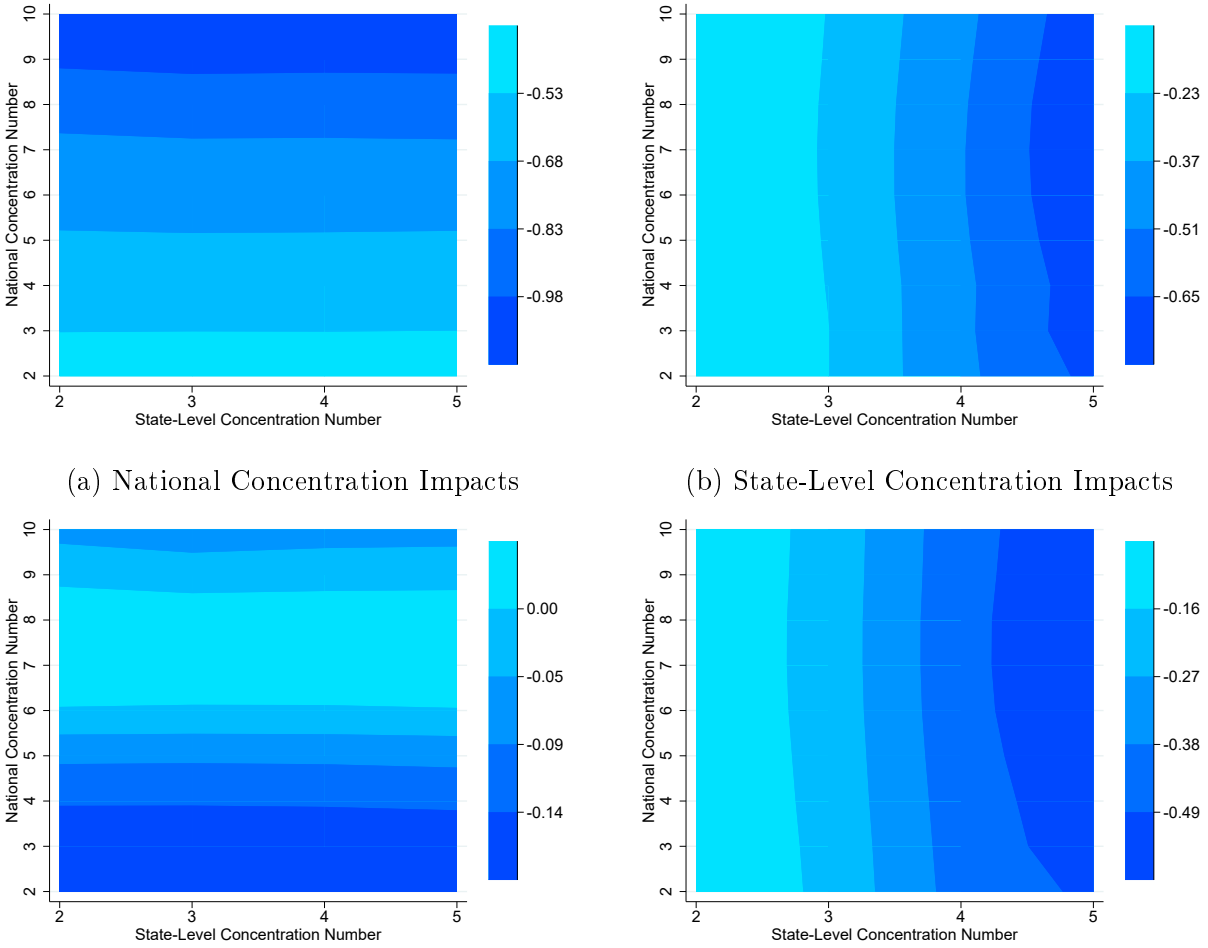
(a) National Concentration



(b) State-Level Concentration

Notes: Figure shows the distribution of concentration ratios for CR-2 through CR-20 at the national (panel a) and state-level (panel b) from 1997–2019.

Figure A2: Effects of Increased Concentration on Poultry Worker Wages



(a) National Concentration Impacts

(b) State-Level Concentration Impacts

(c) National Concentration Impacts

(d) State-Level Concentration Impacts

Notes: Figure reports the effects of increased national and state-level ownership concentration on poultry processing plant worker wages. Panels (a) and (b) report results for the composite wage model and panels (c) and (d) report results for the construction wage model. For specifications of equation (4) including all combinations of national concentration ratios CR-2^{US} to CR-10^{US} and state-level concentration ratios CR-2^{State} to CR-5^{State}, panels (a) and (c) of the Figure reports the effects of national concentration and panels (b) and (d) reports the effects of state-level concentration.

Table A3: Increased Concentration and Poultry Worker Wages—TWFE Design

	(1)	(2)	(3)	(4)
	State-Level Concentration Ratio Specification			
	CR-2	CR-3	CR-4	CR-5
CR-N^{State}	-0.075**	-0.200***	-0.405***	-0.569***
	(0.029)	(0.069)	(0.118)	(0.158)
Constant	6.333***	6.457***	6.663***	6.830***
	(0.026)	(0.066)	(0.115)	(0.157)
Group FX	Yes	Yes	Yes	Yes
Year FX	Yes	Yes	Yes	Yes
Observations	432	432	432	432
R^2	0.96	0.96	0.96	0.96

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1