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Market Power in Poultry Production Contracting? Evidence from a Farm Survey

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The exercise of market power by broiler processing firms (integrators) is plausible because local markets for growers are concentrated and because growers face hold-up risks arising from substantial investments in specific assets set against limited integrator purchase commitments. This article explores the links between local integrator concentration and grower compensation under production contracts using data from the 2006 broiler version of the USDA's Agricultural Resource Management Survey. Results of this study, which account for characteristics of the operation and specific features of the production contract, suggest that greater integrator concentration results in a small but economically meaningful reduction in grower compensation.

Key Words: broilers, market power, monopsony, oligopsony, poultry, production contracts

JEL Classifications: L11, L13, Q12

High and growing concentration in meatpacking markets has raised concerns over the exercise of market power in livestock procurement. Those concerns were an important element in public workshops, held jointly by the Department of Agriculture and the Department of Justice during 2010, on "Agriculture and Antitrust Enforcement Issues in our 21st Century Economy."[1] Competition in cattle, hogs, and poultry were a major focus of workshop discussion. Although market power is usually defined for product markets as the ability to set price profitably above marginal cost, in input markets it can be defined as the ability to set price profitably below the value of marginal product.

Competition concerns are not new. Four firm concentration in fed cattle purchases rose from 41% in 1982 to 80% in 1997, whereas concentration in hog purchases rose from 32% to 64% between 1985 and 2005. There exists an extensive literature assessing concentration and competition in markets for fed cattle and a smaller but still considerable set of studies focusing on market hogs. In contrast, there has been little research focused on poultry.[2]

In this article, we assess the impact of local market concentration on the fees paid by integrators to contract broiler growers. Four firm concentration in broiler production rose from

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[1] www.justice.gov/atr/public/workshops/ag2010/index.html.

[2] For a recent review of this literature see RTI International (2007), known as the Livestock and Meat Marketing Study, which was sponsored by USDA's Grain Inspection, Packers and Stockyards Administration (GIPSA).

41% in 1991, to 53% in 2009. However, because broiler companies truck feed to contract growers and truck the live birds from growers to processing plants, they will generally seek contract growers in reasonably close proximity to their complexes, and relevant markets for poultry growers are therefore quite localized. As a result, the number of relevant buyers for grower services is likely to be considerably lower than national concentration measures suggest.

For example, in its challenge to a 2011 merger, the U.S. Justice Department argued that the Shenandoah Valley in Virginia constituted a relevant local market for growers' services with three integrators, Tyson Foods, George's, and JBS/Pilgrim's Pride. Vukina and Leegomonchai (2006) used a survey of growers in 10 states in their analysis of markets for poultry growers. The survey asked growers to report the number of companies that were currently offering broiler contracts in their area.[3] The mean number of buyers was 2.48 and 28% of the respondents reported a single buyer for their services. We find similar responses for our survey of growers and we find that concentration matters, in that fees received under production contracts are lower where there are fewer integrators.

Contracting and Concentration in Local Markets for Growers' Services

Studies of competition in fed cattle and hog markets analyze prices paid for livestock and follow standard practices in the industrial organization literature. Some relate variations in livestock prices to differences in buyer concentration across local markets or over time, whereas others estimate structural models of livestock demand, processor costs, and livestock supply and aim to identify gaps between marginal value of a product and observed prices paid for livestock. These approaches are not feasible in broiler production because there are virtually no market transactions, and hence no reported prices, for live broilers.

Broiler production occurs within localized complexes consisting of hatcheries, broiler grow-out farms, feed mills, slaughter plants, and further processing plants. Firms called integrators usually own and operate the hatcheries, feed mills, and plants and contract with farmers to raise broiler chicks in the "grow-out" stage. Some contract growers raise replacement birds for the hatcheries, whereas most raise birds for meat.

Economies of scale in slaughter, hatcheries, and feed mills provide incentives to concentrate large facilities near the center of a production complex. Because transportation costs for feed, chicks, and birds are significant, total grow-out costs can be reduced by contracting with farms that are near hatchery, slaughter, and feed facilities. Although geographic concentration is constrained by the pollution and biosecurity risks that would arise from concentrating grow-out in a few very large operations, complexes nevertheless operate in very localized markets. Growers can contract with competing integrators only when the geographic scope of production complexes overlap.

Procurement markets in broilers are markets for growers' services, not for live poultry, and the relevant prices are therefore payments made to growers. Integrators provide contract growers with chicks, feed, and veterinary services and may also reimburse them for some expenses (such as utilities). Growers provide labor, capital, management services, and most utilities. For each flock delivered, farmers receive a base price and an incentive payment that varies with their performance relative to other growers delivering flocks in the same period. The incentive payment can be positive

[3] We know of no data on four firm concentration in local poultry markets. With fewer than five buyers in a market (which we argue is true for most local markets), a four-firm concentration ratio is not very informative, because it will always equal 100 with no variation as the number of buyers varies between one and four. When needed for investigations, antitrust agencies define relevant local markets and count the number of buyers. In our survey as well as the one used by Vukina and Leegomonchai (2006), growers are asked for the number of buyers in their area. This approach relies on the respondent's judgment of the scope of the term "area," but growers should be quite well versed with the different poultry companies available to them, and this measure will also capture variations in buyer numbers in highly concentrated markets.

or negative, and relative performance varies with flock mortality and feed conversion; those that deliver the most broiler meat, given the quantity of feed and chicks provided, receive the highest incentive payments (Knoeber, 1989).

Poultry growers provide labor and management time, but they also make a substantial commitment of capital that is highly specific to poultry production. Growers invest in poultry houses and in associated equipment for feed storage and distribution, water delivery, and climate control. A fully equipped modern broiler house of 25,000 square feet will likely cost over $200,000 for the structure and equipment with additional expense required for land, and most producers operate multiple houses (Cunningham, 2011). Houses can last for 30 years or more, and their value in an alternative use is very low.

Grower contracts are incomplete in that much that is relevant to the relationship is left implicit without written specifications to cover all possible contingencies. Few are written for long durations, and many cover only a single flock (MacDonald, 2008). Integrators rarely commit to quantity or compensation guarantees.[4] Because investments are long-term, geographically specific, and product-specific, and because contracts are incomplete, growers face distinct hold-up risks (Klein, Crawford, and Alchian, 1978; Williamson, 1979). Essentially, growers able to choose among several occupations before their initial investment may be locked into broiler production after making the investment. In that case, an oligopsonist or monopsonistic integrator may be able to set contract renewal terms in such a way as to just cover the grower's incremental costs of continuing production but to expropriate all rents.

Of course, actual and potential growers have strong incentives to recognize and react to the potential for hold-up. They can limit their investment, limit their effort after making the investment, or seek stronger contract guarantees. The essence of the hold-up problem is that it may lead to outcomes that "leave money on the table," destroying rents and leaving each side worse off than they would be if they could write a complete contract.

Vukina and Leegomonchai (2006) find evidence of hold-up risks in the industry as well as evidence that local integrator concentration is relevant. Specifically, growers in locations with fewer integrators built fewer houses in their initial investment, and those in locations with only one or two integrators made fewer significant upgrades to their houses.[5] Finally, they found that upgrades were less likely to lead to improved net cash flow for growers in markets with a single integrator as compared with other markets. Thus, integrator concentration, by increasing hold-up risks, affected grower investment decisions and outcomes.

This article assesses the impact of local integrator concentration on contract grower compensation—payments per pound of broilers produced—using data from the 2006 broiler version of USDA's Agricultural Resource Management Survey.[6] Specifically, we test the hypothesis that integrators are able to reduce payments to growers in markets with fewer integrators.

Grower contracts are not uniform, and a variety of other factors affect contract fees. In particular, differences in the technology used on broiler operations affect relative performance. Contract attributes also vary across growers; some affect production costs directly, whereas others assign responsibility for expenses, for assets or for valuable byproducts, to integrators,

[4] Grower contracts for hogs differ in this respect in that they often base compensation on pig spaces, rather than pigs raised, and they typically cover longer durations.

[5] Housing technology changes over time, and growers may upgrade houses to install improved climate controls or feeding and watering equipment, and they may occasionally reconstruct houses. Growers may do this on their own, because they expect the investments to improve their performance, or they may be required to do so as a condition of contract renewal.

[6] ARMS data do not allow us to replicate the investment-based analyses of Vukina and Leegomonchai (2006). While the survey gathered information house characteristics, it did not ask about the number of broiler houses originally constructed on a farm, and it did not include questions on the number of significant upgrades to the houses.

growers, or third parties. These grower and contract attributes will often affect fees paid, so we aim to control for them in the analysis.

Data on Broiler Production Operations

A large-scale representative survey of broiler producers was conducted early in 2007 as part of the annual Agricultural Resource Management Survey (ARMS). ARMS is the U.S. Department of Agriculture's primary source of information on the financial conditions of farm businesses and farm households and the production practices of farms. In any given year, several survey versions are distributed; two focus on all types of farms, whereas others focus on producers of specific commodities. A broiler version was included, for the first time, in the ARMS conducted for the 2006 reference year.[7]

The 2006 broiler version focused on commercial producers of broilers grown for meat, excluding operations that raise broilers for show or for private consumption as well as egg, hatchery, and replacement bird farms. To meet that goal, a sample was drawn from a target population consisting of all operations in major broiler states that produced broilers for meat and that had at least 1,000 broilers on-site at any time during 2006.[8]

To obtain more reliable estimates, some types of farms have a higher probability of sample selection. For example, larger operations are more likely to be selected for inclusion than smaller, and selection probabilities also vary across geographic areas. Each sample farm then represents a number of other farms from a similar geographic location and size class. In the broiler version, weights (the number of farms that each sample point represents) range from three to 40 operations. When sample observations are weighted to reflect selection probabilities, population estimates for production and other industry characteristics can be generated.

Of 2,100 operations in the target sample for the broiler version, 1,602 useable survey responses were received. However, 34 of the respondents, while they were still in farming, did not produce broilers for meat during 2006, leaving 1,568 broiler producers for analysis (a 75% response rate). Once the weights were recalibrated for nonresponse, the sample of useable responses represented 17,440 producers and production of 8.4 billion broilers in 2006 (Table 1).[9]

Our analysis focuses on 1,546 respondents who reported having a production contract for broilers; the other 22 were independents, processor-owned, or did not respond to the question. Three of those with production contracts reported no broiler removals (that is, birds moved from the farm to slaughter plants), so we exclude them from our later analysis. Farms with production contracts accounted for 98.5% of total broiler production in the 17-state sample (Table 1).

There is a wide range of farm sizes in the industry with some operations reporting as many as 18 broiler houses. However, 70% of broiler operations had one to four houses in 2006, and they accounted for just under half of production as measured by birds or by liveweight pounds (Table 2). Although production has been shifting to larger operations, very large operations, with 10 or more houses, still represent a small share of the industry—2.8%

[7] Further information about ARMS, including downloadable copies of the questionnaires used, can be found at www.ers.usda.gov/Briefing/ARMS/.

[8] The 17 major broiler states, which accounted for 94% of broiler production in the 2002 Census of Agriculture, were Alabama, Arkansas, California, Delaware, Georgia, Kentucky, Louisiana, Maryland, Mississippi, Missouri, North Carolina, Oklahoma, Pennsylvania, South Carolina, Tennessee, Texas, and Virginia.

[9] We can gauge the accuracy of our estimates by comparing with slaughter statistics, which are derived separately and reported for 15 of our 17 states in *Poultry Slaughter* (USDA/NASS). Total 2006 slaughter in those states was 7.96 billion birds compared with estimated production of 8.09 billion in the survey (production should exceed slaughter). We can also compare grower numbers to the Census of Agriculture, which reports 20,778 farms with broiler production contracts in 2002 and 17,001 in 2007 compared with our estimate of 17,183 farms in 2006.

Table 1. Broiler Production in 2006, by Type of Operation

	All Farms		Farms Reporting Broiler Removals		
Type of Operation	Obs.	Farms	Obs.	Farms	Removals
Production contract	1,546	17,200	1,543	17,183	8,310,308,738
Processor-owned	12	163	12	163	84,166,446
Independent	6	52	6	52	31,411,423
More than one type	2	14	2	14	8,219,932
Refusal/do not know	2	11	2	11	5,265,540
All operations	1,568	17,440	1,565	17,423	8,439,372,079

Notes: The number of observations is columns labeled "Obs.," whereas columns labeled "farms" and "removals" report weighted population estimates. Three sample farms reported that they had production contracts but failed to report the number of birds removed.
Source: 2006 Agricultural Resource Management Survey, version 4.

of production contract operations and approximately 10% of production.[10]

Concentration in Local Markets for Growers

Our concentration measures are grower-reported; that is, survey respondents were asked for the number of broiler companies operating in their area. Local markets are concentrated with the mean number of integrators at 2.65. Monopsony (a single integrator in the grower's area) accounts for almost one-fourth of operations (Table 3), whereas another 28.7% report having two integrators and 21.7% report having three. The highest number of companies reported is nine, and just over one-fifth of operations report four or more in their area.[11]

Growers who reported a single broiler company in the area received average fees of 4.82 cents per pound of broilers (live weight) removed, approximately 6% less than the 5.14 cents received by growers in regions with four or more companies, and the difference was statistically significant (Table 3). Growers who report two or three broiler companies receive average fees of just over 5 cents per pound, significantly different from those with one or more than three.

The survey provides us with two ways to calculate grower payments. Respondents report their total payments received from broiler production during 2006 as well as production number of birds and total live weight removed. That allows us to calculate a "unit value" fee per pound, which is what is reported in Table 3 and used as the dependent variable in the first set of regressions. The survey also asks respondents directly for their average fee per pound. We expect that the latter might be more subject to error because growers deliver multiple flocks during the year, and the fees that a grower receives will usually vary across flocks. The two measures provide almost exactly the same average values (5 cents a pound for each median and the overall means differ by 0.002 cents), and they are strongly correlated with one another (a correlation coefficient of 0.90). Our models provide a modestly better fit for the unit values than for the average fees, although the effect of competition is slightly stronger for average fees.

Technology, Contract Terms, and Fees

Other factors may affect the fees received by growers. Growers typically receive a base payment, but their total compensation also

[10] Half of 2006 production came from farms with at least 605,000 broilers removed (equivalent to five houses), and half came from smaller operations. Hoppe et al. (2007) show that this midpoint farm size was 300,000 broilers in 1987 and has been increasing since then. Nevertheless, the midpoint farm is still relatively small—600,000 broilers, at average bird sizes and grower fees, would generate revenues of just over $160,000 in 2006.

[11] This is similar to the findings of Vukina and Leegomonchai (2006), who report that 28% of growers reported a single integrator in their area with a mean response of 2.5 integrators.

Table 2. The Size Distribution of Broiler Operations in 2006

	Farms	Broilers Removed	Pounds Removed	Capacity (square feet)
Total	17,183	8,310 million	44,815 million	1,221 million
By Number of Houses			Percent of Column Total	
None	0.5	0.2	0.2	0
1–2	27.3	11.6	10.7	11.0
3–4	43.1	38.0	37.4	38.0
5–6	18.7	25.4	26.0	25.0
7–8	6.1	10.9	11.3	11.8
9–10	1.7	4.2	4.2	4.2
11–12	1.2	3.4	3.6	3.5
13–18	1.6	6.4	6.7	6.6
All farms	100.0	100.0	100.0	100.0

Notes: Observations are weighted by inverse sampling probabilities to yield population estimates. The row labeled "None" includes operations that refused to provide information on houses or that reported that they had no houses.
Source: 2006 Agricultural Resource Management Survey, version 4, production contracts only.

depends on their relative performance, and payments will vary with those features of the farm's technology that encourage greater efficiency. Base payments and contract features can vary across growers and regions. Some contract features impose higher costs on growers, who may be compensated with higher base payments. Other features may assign more expenses to integrators, which may lead to lower contract fees paid. Rights to valuable litter byproducts may be assigned to integrators, growers, or third parties with consequent impacts on contract payments.

Table 4, which reports descriptive statistics for the variables used in the analysis, also provides useful summaries of the technological features of broiler operations' houses and the terms of trade observed in production contracts. Newer houses tend to be larger and to have climate controls that allow for greater capacity use and greater efficiency. The mean age of a farm's housing stock was 17.3 years in 2006 with a wide variation across operations. Just over 73.5% of housing capacity was fitted with tunnel ventilation, which allows for better climate control in houses.[12]

Although integrators provide feed and veterinary services under most production contracts, they may also pay for other expenses, and these features should affect base payments. In nearly one-fourth of contracts, the integrator pays for at least part of the grower's fuel or litter expenses, whereas the integrator bears custom work expenses, for catching or clean-out, in nearly half of contracts.

With regard to contract features, some contracts (5.3%) specified prices for energy purchased from a specific dealer, whereas most (55.7%) adjust fees seasonally for changes in fuel prices. Most contracts were short-term; only 13.9% of operations currently had contracts that lasted at least 5 years.

Just over half of farms had a HACCP food safety plan required in the contract. Just under half reported that no antibiotics were provided in their feed, a practice closely linked to HACCP use–31.2% of farms had both practices.[13] A HAACP plan likely imposes higher costs on growers, whereas doing without antibiotics for

[12] Operations usually had tunnel ventilation in all or none of their houses. The survey also gathered information on housing construction (solid walls or curtains) and other technology such as evaporative cooling. These are strongly correlated with tunnel ventilation.

[13] HACCP (hazard analysis critical control points) plans aim at biosecurity and food safety on broiler farms. The plans identify points in the production process where human or animal pathogens might be introduced and specify procedures for monitoring and reducing pathogen populations in broilers, houses, equipment, and workers. If HACCP sanitation, ventilation, and testing procedures work, they can also reduce on-farm antibiotics use, and HACCP plans seem to be primarily used by farms that do not provide antibiotics in feed (MacDonald and Wang, 2011).

Table 3. Concentration in Broiler Grow-out

	Number of Integrators in Grower's Area			
Item	1	2	3	4 or More
Share (%) of all				
Broiler operations	24.5	28.7	21.7	25.1
Birds removed	24.7	29.8	22.7	22.7
Mean				
Number of houses	4.2	4.3	4.2	3.9
Age of houses (years)	17.7	17.5	18.4	18.5
Fees received (cents/lb)	4.82	5.05	5.03	5.14

Notes: Producers were asked for the number of broiler companies in their area. Observations were weighted by inverse sampling probabilities to yield population estimates. There was no statistically significant difference in mean fees received between growers with two integrators and those with three, but other differences in fees were statistically significant at a 5% level using standard and jackknife standard errors.
Source: 2006 Agricultural Resource Management Survey, version 4, production contracts only.

disease prevention or growth promotion may lead to higher mortality and poorer feed conversion.

Opportunity Cost of Labor

Nonfarm employment options may affect integrator market power in that high local wages may spur growers to reject poor contract offers and leave contract production.[14] We constructed a county-level measure of nonfarm opportunities: expected annual nonfarm compensation per worker, which is the product of the nonfarm employment rate and nonfarm annual compensation per job in the grower's county.[15] This measure has an average value of $32,440 for our sample and varies substantially across counties.

Estimating the Effect of Integrator Concentration on Growers' Fees

We want to explore how grower compensation varies with features of technology, contracts, and integrator numbers. Our regression analysis thus follows one line of structure–conduct–performance (SCP) analyses from the industrial organization literature, those that link observed market prices to measures of concentration (Weiss, 1989). Most such studies rely, like this one, on cross-sections of local markets for the same product or service and compare differences in prices as concentration varies across markets. They differ from earlier SCP studies that evaluated cross-industry variations in profits, whose focus on profits often left them unable to effectively distinguish market power from efficiency (because high profits could follow from high prices or low costs). They also differ from new industrial organization (NEIO) studies that aim to identify market power by estimating structural models of demand and production and (in input markets) identifying a wedge between input prices and their estimated competitive counterparts. NEIO studies often rely on time series data to generate demand and production parameters at the cost of primitive specifications of technological change

[14] Moreover, local market wages could be correlated with industry concentration. In studies of monopsony power in markets for nursing services, it has been noted that hospital concentration is lower in larger cities, where living costs and nonhospital wages are generally higher. This could result in a spurious negative correlation between hospital concentration and wages if the opportunity cost of nurses' labor is not adequately controlled for.

[15] The nonfarm employment rate is one minus the county nonfarm unemployment rate provided by the Bureau of Labor Statistics Local Area Unemployment Statistics. Nonfarm annual compensation per job is annual nonfarm income (wages and salary plus benefits) divided by nonfarm employment (number of jobs) from the Bureau of Economic Analysis Local Area Personal Income data. To better capture the long-run economic conditions in the county, we used the average value of the expected annual compensation from 2002 to 2006.

Table 4. Descriptive Statistics for Variables Used in the Analysis

Variable Description	Units	Mean	Standard Deviation
Total pounds removed (live weight)	lbs	2,687,215	6,676,856
Average broiler weight	lbs	5.58	4.88
Fees from broiler production	dollars	133,914	343,582
Fees/total pounds removed	cents/lb	5.01	3.38
Average fee per pound removed	cents/lb	5.01	3.32
Age of housing stock	years	17.3	27.3
Share of capacity with tunnel ventilation	0–100%	0.735	1.395
Capacity utilization (lbs removed)	lbs/sq ft	36.6	31.4
Share of capacity owned by integrator	0–100%	0.015	0.192
Fees adjusted seasonally for fuel prices	0–1	0.557	
Contract specified prices for energy	0–1	0.053	
No antibiotics in feed and HACCP plan required	0–1	0.312	
Contractor reimburses litter or fuel	0–1	0.239	
Contractor reimburses custom work	0–1	0.451	
Contract of 5 years or more	0–1	0.139	
Expected annual off-farm compensation	1,000 dollars	32.44	13.94

Notes: Observations are weighted by inverse sampling probabilities to yield population estimates. The "average fee per pound" is asked directly on the survey, whereas "fees/total pounds removed" is calculated based on reported fees and reported pounds removed.
Source: 2006 Agricultural Resource Management Survey, version 4, production contracts only.

and demand shifts. Although SCP price studies rarely have the data available to specify structural models of cost and production, the best among them offer excellent data on prices, competition, and technologies to establish robust empirical relationships (Sexton and Lavoie, 2001).

We analyze several linear regressions, each using a measure of contract fees as the dependent variable (the unit value fee per pound, the average fee per pound, the log of that measure, and the log of total annual compensation). The set of explanatory variables includes the measures of contract features, technology and operation characteristics reported in Table 4 as well as the binary competition measures reported in Table 3.

We dropped some observations with extreme values of the dependent variable, whereas others had to be deleted because they had missing values for some variables. Specifically, we dropped any observation with reported fees (in unit values) of less than 2.5 cents or more than 12 cents per pound on the grounds that fee revenues, broiler removals, or accounts receivable were likely misreported. We also dropped records that had contracts for organic broilers. Seventy of the 1,543 observations were dropped for these reasons; 86 other respondents did not provide data on some housing characteristics, leaving us with 1,387 observations for analyses of the links among technologies, contract features, competition, and fees.

All regressions used weighted least squares with observations weighted to reflect their ARMS sampling probabilities. They also include fixed state effects and rely on classical tests of inference. The ARMS, like many surveys, is derived from a complex survey design and may require alternative estimates of standard errors and tests of inference. We summarize the issues and report further tests in Appendix A.

Regression Results

We explore several regression models aimed at explaining variations in fees received by growers. The four regressions reported in Table 5 use the unit value (total annual fees divided by pounds delivered) as the dependent variable and different sets of explanatory variables. Regression (1) controls for the

Table 5. Effects of Integrator Concentration on Contract Fees: Alternative Model Specifications

	Regression Coefficients and t Statistics			
Dependent Variable	(1) Fees/lbs	(2) Fees/lbs	(3) Fees/lbs	(4) Fees/lbs
Intercept	5.489 (31.13)	6.258 (27.71)	6.043 (26.19)	6.323 (19.90)
Operation characteristics				
Average weight of birds (lbs)	–0.092 (–5.01)	–0.136 (–6.67)	–0.138 (–6.81)	–0.138 (–6.83)
Number of integrators				
One	–0.413 (–5.28)	–0.373 (–4.78)	–0.379 (–4.83)	–0.394 (–4.96)
Two	–0.195 (–2.48)	–0.178 (–2.29)	–0.191 (–2.46)	–0.203 (–2.59)
Three	–0.064 (–0.80)	–0.182 (–2.24)	–0.217 (–2.68)	–0.220 (–2.71)
Housing characteristics				
Mean age		–0.013 (–3.82)	–0.011 (–3.14)	–0.010 (–3.06)
Percent tunnel ventilated		0.453 (6.26)	0.434 (6.03)	0.438 (6.08)
Pounds removed per square foot		–0.014 (–4.91)	–0.013 (–5.08)	–0.013 (–5.07)
Owned by integrator		–0.730 (–1.67)	–0.789 (–1.83)	–0.802 (–1.86)
Contract terms				
Fee adjusted for fuel prices			0.088 (1.56)	0.087 (1.54)
Contract specifies energy prices			0.229 (1.92)	0.231 (1.93)
No antibiotics in feed and HACCP plan required			0.151 (2.76)	0.150 (2.75)
Litter or fuel expenses reimbursed			–0.344 (–2.97)	–0.347 (–3.00)
Custom work reimbursed			0.202 (2.76)	0.199 (2.72)
Long-term contract			0.204 (2.68)	0.204 (2.68)
Expected off-farm compensation				–0.009 (–1.28)
State fixed effects	Yes	Yes	Yes	Yes
Observations	1473	1387	1387	1387
R^2	0.10	0.16	0.18	0.18

Note: t statistics are in parentheses. The dependent variable is total annual contract fees received divided by total live weight pounds delivered.
Source: 2006 Agricultural Resource Management Survey, version 4, production contracts only.

average weight of the birds sold, the number of integrators in the operator's area, and state fixed effects.[16] Regression (2) introduces housing characteristics, whereas regression (3) introduces contract terms, and regression (4) adds a measure of the opportunity cost of operator labor. A second set of four regressions (Table 6) uses the full set of exogenous variables from regression (4) of Table 5 but explores different measures of the contracting fee.

In evaluating the results, it is important to bear in mind the range of fee payments received by growers. The mean fee was 5.01 cents per pound, whereas 90% of the observations fell in a range of 2.24 cents, from 3.89–6.13 cents per pound. The results display several consistent patterns (Table 5).

First, bird size affects fees in an economically substantive manner. Operations producing larger birds realize higher fees per bird but lower fees per pound. In regression (1), a 1-pound increase in the size of the bird is associated with a 0.09 cent reduction in fees per pound (bird sizes range widely in the data, from 3–9 pounds). As more

[16] State fixed effects are included to account for unobserved factors that might explain variation in fees such as differences in the environmental or business regulations. For example, some states have adopted statues governing contract termination (Tsoulouhas and Vukina, 2001).

Table 6. Effects of Concentration on Contract Fees: Alternative Measure of Fees

	Regression Coefficients and t Statistics			
Dependent Variable	(5) Fees/lbs	(6) Average fee/lb	(7) Ln (average fee/lb)	(8) Ln (fees)
Intercept	6.323 (19.90)	5.918 (17.87)	1.974 (12.13)	–2.155 (–10.19)
Operation characteristics				
Ln (number of birds removed)				0.974 (97.59)
Average weight of birds (lbs)[a]	–0.138 (–6.83)	–0.154 (–7.24)	–0.168 (–7.86)	0.836 (38.06)
Number of integrators				
One	–0.394 (–4.96)	–0.417 (–5.05)	–0.074 (–4.88)	–0.072 (–4.81)
Two	–0.203 (–2.59)	–0.249 (–3.04)	–0.046 (–3.09)	–0.041 (–2.75)
Three	–0.220 (–2.71)	–0.285 (–3.37)	–0.054 (–3.48)	–0.043 (–2.80)
Housing characteristics				
Mean age[a]	–0.010 (–3.06)	–0.008 (–2.40)	–0.025 (–2.57)	–0.031 (–3.04)
Percent tunnel ventilated	0.438 (6.08)	0.409 (5.40)	0.091 (6.61)	0.097 (7.14)
Pounds removed per square foot	–0.013 (–5.07)	–0.009 (–3.14)	–0.001 (–2.74)	–0.002 (–3.52)
Owned by integrator	–0.802 (–1.86)	–0.456 (–0.94)	–0.085 (–0.95)	–0.096 (–1.14)
Contract terms				
Fee adjusted for fuel prices	0.087 (1.54)	0.108 (1.84)	0.028 (2.58)	0.026 (2.42)
Contract specifies energy prices	0.231 (1.93)	0.170 (1.34)	0.034 (1.49)	0.046 (2.03)
No antibiotics in feed and HACCP plan required	0.150 (2.75)	0.137 (2.39)	0.025 (2.37)	0.026 (2.49)
Litter or fuel expenses reimbursed	–0.347 (–3.00)	–0.292 (–2.42)	–0.064 (–2.91)	–0.082 (–3.72)
Custom work reimbursed	0.199 (2.72)	0.153 (2.00)	0.031 (2.25)	0.040 (2.94)
Long-term contract	0.204 (2.68)	0.146 (1.84)	0.030 (2.05)	0.044 (3.08)
Expected off-farm compensation[a]	–0.009 (–1.28)	–0.003 (–0.41)	–0.027 (–0.63)	–0.057 (–1.32)
State fixed effects	Yes	Yes	Yes	Yes
Observations	1387	1368	1368	1387
R^2	0.18	0.15	0.18	0.93

Note: t statistics in parentheses.
[a] Natural log of variable used when dependent variable is logged (columns 3 and 4).
Source: 2006 Agricultural Resource Management Survey, version 4, production contracts only.

controls are added, the effect of bird size increases to nearly 0.14 cents per pound (regressions 2–4).

Second, housing characteristics affect fees received in statistically significant and economically meaningful ways (regressions 2–4). Operations with tunnel ventilation realize higher fees—approximately 0.45 cents per pound, or an 8% increase, on average.[17] Controlling for tunnel ventilation, operators with older houses earned lower fees: approximately 0.01 cent lower for each additional year increase in the average age of the houses. Housing capacity utilization is negatively associated with fees; increasing the quantity of broiler meat removed by 1 pound per square foot lowered the fee by approximately 0.01 cents per pound. Having a larger share of the operation's housing owned by the integrator also resulted in a lower fee.

Third, contract features matter in economically meaningful ways. We included six features

[17] Better climate control raises grower costs but should raise fees because they increase feed efficiency and reduce mortality.

of contracts in the model, all specified as 0–1 dummy variables (regression 3). Among the more important effects, operations with long-term contracts (5 years or more) received fees that were approximately 0.20 cents, or 4%, higher than others. Operations that reported that there were no antibiotics in their feed and that were required to have a HACCP plan received fees that were 0.15 cents higher. Those whose fees were adjusted for changes in fuel prices received 0.09 cents more per pound in 2006. Operators whose contracts tied them to specific energy dealers received noticeably higher fees (0.23 cents per pound), and those whose litter or fuel expenses were paid for by the integrator received lower contract fees (0.34 cents per pound). Operators whose custom work expenses were paid for by the integrator received higher fees (0.20 cents per pound), perhaps because custom work involved litter cleanout and transfer of the litter to the integrator or a third party.

Results indicate a negative, although not statistically significant, relationship between the expected off-farm compensation and contract fees (regression 4). Including alternative measures of the local nonfarm and farm compensation rates did not alter the magnitude or significance of the concentration indicators.[18]

Finally, competition, as measured by the number of integrators in a local area, matters. We specify our model with a set of dummy variables for the number of integrators (1, 2, 3, with the base being four or more) rather than choose a single continuous variable with the number of integrators, because the relationship between the number of competitors and price is unlikely to be linear.[19] Compared with areas with four or more integrators, growers in areas with a single integrator receive fees that are 0.37–0.41 cents per pound lower (approximately 8%), whereas growers with two integrators receive fees that are 0.18–0.20 cents per pound lower. Each of these estimates is slightly larger than the magnitudes apparent in the simple comparisons of Table 3 and is robust to the inclusion of additional control variables in regressions 2–4. The magnitude of these effects is fairly small, although that finding is generally quite consistent with many other cross-section studies of concentration and price (Sexton and Lavoie, 2001; Weiss, 1989).

The estimate for three integrators is sensitive to the model. In regression (1), the coefficient is small (–0.06 cents) and not significantly different, but the coefficient jumps to −0.18 to −0.22 cents per pound when controls for housing, contract features, and local compensation rates are added in regressions 2–4. These estimates are little changed from the comparison of simple means and are robust across model specifications. Although measures of housing, contract, and operations characteristics improve the fits of the equations, and these measures appear to affect fees paid, their inclusion has little impact on the estimated effects of the number of integrators.

In Table 6, we compare our results with analyses done with alternative measures of fees paid. Regression 5 repeats regression 4 (Table 5) for ease of comparison. In regression 6, we replace the unit value estimate of fees per

18 Integrator transportation costs might also affect contract terms; it is plausible that an integrator would offer better terms to growers located closer to the feed or processing facility. Unfortunately survey data on transportation costs or grower distance to facility are not available to test this hypothesis. As a proxy for grower distance, we included in a regression (not reported here) measures of grower density within the county (growers and birds, per square mile, in the 2007 Census of Agriculture). Neither measure had an impact on fees or on the "number of integrators" coefficients. Hence, these measures provided no evidence that excluding a measure of grower distance to the processor biases our estimates of the key parameters.

19 In oligopoly theories (such as the basic Cournot model as well as basic and extended Bertrand models), the relation between the number of competitors and prices is nonlinear, and changes in the number of competitors have a larger impact on price when the number of competitors is small. The Merger Guidelines issued by the Department of Justice embody a nonlinear relationship, based on the Cournot model, when they rely on a Herfindahl index of concentration to identify mergers likely to raise competitive concerns. Empirical studies that test for nonlinearity (MacDonald, Handy, and Plato, 2002; Weiss, 1989) frequently find that the effects vary with the number of players within markets that are quite concentrated.

pound with the grower's reported average fee per pound. In general, the fit of the model deteriorates and the coefficients on housing characteristics and contract terms become smaller and less significant. However, the competition effects are larger and marginally more significant. The pattern is quite similar in regression 7, in which we use the natural logarithm of the average fee.

Finally, in regression (8) we use total annual fees (in log form) as the dependent variable and add the log of total birds removed as an explanatory variable. The model accounts for 93% of the variation in total log revenue. Revenues increase then proportionately with the number of birds. Given total birds removed, increases in bird size add to revenues but less than proportionately to weight (that is, larger birds generate lower revenues per pound). In general, the terms for housing characteristics and contract terms are a bit larger with higher t statistics. In particular, note that growers with long-term contracts (5 years or more) receive fees that are 4% higher, suggesting that these are growers are in relatively strong bargaining positions.

Finally, the competition effects are robust: growers with a single integrator receive revenues that are 7% lower, on average, and growers with two or three integrators receive revenues that are 4% lower than those with four or more integrators.

Conclusions

We do not have the data to develop a comprehensive NEIO model of local markets for grower services; such a model would account for grower alternatives, identify a grower supply function, and estimate the degree to which concentration might allow for the suppression of grower returns relative to competitive returns. Instead, we report on the association between grower compensation and concentration while accounting for differences in contract terms and technological features.

Nevertheless, the analysis does provide some novel and useful findings. We use a nationally representative survey of broiler producers to show that local markets for grower services are highly concentrated;, slightly more than half of all growers operate in markets where there are one or two integrators, and approximately one-fourth of all growers are operating in markets with only one integrator. We find a small but economically meaningful effect of integrator numbers on grower compensation; growers facing a single integrator are paid 7–8% less, on average, than farmers located facing four or more integrators. This finding is robust to controls for local compensation rates and operation and contract features, factors that were also shown to influence contract compensation and vary considerably across growers. The finding is also robust to alternative methods of measuring compensation and to alternative tests of inference. We develop this finding in the context of an empirical analysis in which contract terms and technology features also affect returns in expected magnitudes. Finally, we should note that, although we characterize the price effects of integrator competition as small, modest differences in revenues can translate into substantial differences in net returns across operations.

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Appendix A: Statistical Inference with ARMS Survey Data

The ARMS sample is developed from a complex survey design. Specifically, the ARMS is a multiframe, multimode, multiversion survey with a stratified sampling design. It has a dual sampling frame: most farms are drawn from a list frame, but because the list frame may miss small and new farms, additional farms are selected from an annual USDA survey of randomly selected areas (an area frame). It is a multimode survey because some respondents receive personal interviews from enumerators, whereas others receive mail versions of the survey. The sampling strata, sorted by size, primary commodity, and location, have different sampling weights, and postsurvey weights are recalibrated to generate population estimates based on useable responses. To minimize respondent burden, farms selected for an ARMS sample in 1 year are less likely to be selected in a following year. A screening procedure is used to screen out farms that are out of scope for the survey or out of business, and these farms are replaced in the sample.

Many surveys have complex designs, and classical methods of statistical inference may not be appropriate for complex survey designs. An ARMS review panel has recommended that researchers use randomization-based inference methods for complex survey designs and specifically recommended the continued use of a jackknife procedure for estimating standard errors and confidence intervals for population estimates (National Research Council, 2008). Jackknife estimators compute estimated standard errors by resampling; each of N groups of observations is dropped in turn, and the estimate of interest is recomputed (Cameron et al., 2005). The resulting empirical distribution of estimates is then used to generate a standard error for the estimate with N-1 degrees of freedom.

Because ARMS records have sampling weights, they must be reweighted to do jackknife estimates. USDA's National Agricultural Statistics Serviceprovides replicate weights in the ARMS research database, and the Economic Research Service provides guides and programs to researchers if they choose to use the jackknife method.

The jackknife procedure does present challenges for inference in regression models. Degrees of freedom in the variance estimator are directly related to the number of replicate weights, which at 15 limits the power of inference tests. Hence, inference tests using the jackknife can be conservative. It is important to emphasize that coefficient estimates are

Appendix Table 1. Tests of Significance for Adding Variable Clusters to the Pricing Model

Model	Description	Critical Value	F Statistic
1	Operation variables only	3.88	21.32
2	Adding housing variables to (1)	3.40	37.70
3	Adding contract terms to (2)	2.52	8.48
4	Adding competition terms to (3)	3.88	7.87

Notes: Variables are identified in Table 5. Critical values are for the upper 1% of the F distribution.
Source: 2006 Agricultural Resource Management Survey, version 4, production contracts only.

Appendix Table 2. Jackknife Variance Estimation for Competition Variables

Equation	Number of Integrators	Parameter Estimate	Classical SE	Jackkknife SE	Jackknife t Statistic
3	1	−0.379	0.078	0.072	5.26
3	2	−0.191	0.078	0.124	1.54
3	3	−0.217	0.081	0.083	2.61
6	1	−0.417	0.083	0.114	3.66
6	2	−0.249	0.082	0.159	1.57
6	3	−0.285	0.085	0.121	2.36

Note: The table reports jackknife estimates of standard errors and associated t-tests for the "number of integrators" variables in equations 3 and 6 from Tables 5 and 6.
Source: 2006 Agricultural Resource Management Survey, version 4, production contracts only.
SE = standard error.

not affected by the jackknife, which focuses on estimation of standard errors.

Moreover, the broiler version of ARMS has a far less complex design that the overall ARMS survey. Sample farms are drawn from a single list frame, and all interviews are personally enumerated; that is, this survey version is single-frame and single-mode. The range of sample weights, three to 40, is much narrower than in the larger survey. In this case, jackknife methods do not provide clear advantages over classical methods of inference.

We have taken three approaches to the issue. First, in the main text, we report weighted least squares estimates with classical estimates of standard errors. We focus discussion on the magnitude of the point estimates of the parameters, which are not affected by jackknife estimation of standard errors, and argue that they are substantively important. We assess the robustness of the estimates of competition by comparing alternative models and alternative measures of compensation. Second, where the features of contracts and technology are concerned, we are not particularly concerned about statistical significance for individual parameters, although we do care whether groups of variables have statistically significant effects on fees. In those cases, we report a series of F-tests on relevant groups of parameters in this appendix. Third, we report tests of inference in this appendix, using jackknife estimates of standard errors, for the individual competition parameters in our model.

Our F-tests are based on the models reported in Table 5. The base model starts with bird weight, expected off-farm compensation, and state fixed effects. Adding the housing variables to that model provides a statistically significant improvement in fit at 1% level. The F-tests indicate that we get further statistically significant improvements in the fit of the model as we add contract terms to the model, and then finally as we add the competition terms (Appendix Table 1).

Finally, we report jackknife estimates of standard errors for the competition variables in Appendix Table 2. The procedure was followed for two models—equation 3 with unit value fees and equation 6 with reported average fees—and we report estimates only for the competition variables to save space. Because parameter estimates remain unchanged, the emphasis should be on standard errors and t tests.

In equation 3, the jackknife standard errors for one and three integrators are essentially unchanged, and the parameter estimates are significantly different from one another and from four integrators. However, the standard error on two integrators is considerably larger, and the difference between two and four integrators, although still negative, is no longer statistically significant when using jackknife estimates of standard errors. The same qualitative conclusion holds in equation 6, in which all jackknife standard errors are noticeably larger; the parameter estimates are all negative, but that on two integrators is no longer statistically significant.