Oligopsony Power, Asset Specificity, and Hold-Up: Evidence from the Broiler Industry

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In this article we look for empirical evidence of hold-up in broiler industry production contracts by using the cross-sectional national survey of broiler growers. First, we focus on the problem of under-investment and hypothesize that the degree of agent's (grower's) under-investment systematically depends on the principal's (integrator's) market power and the level of asset specificity. Second, we provide an indirect test of hold-up by looking at the grower contract payoffs as a function of the frequency of the housing facilities upgrade requests and the principal's market power. The results show moderate empirical support for the presence of hold-up.

Key words: efficiency wage, post-contractual opportunism, property rights theory.

The use of contracts to vertically coordinate the production and marketing of agricultural commodities has become common practice in many agricultural sectors. Commodities such as tomatoes and broilers have been produced almost exclusively under contracts between processors and independent growers for decades. For example, in broiler industry contracts, processors control almost every aspect of production from the distribution of inputs (chicks and feed) to decisions about when to harvest mature birds and repopulate houses with new flocks. Most contracts are written such that they cover one flock at the time. In order to contract production of chickens with a processor a grower is required to construct housing facilities and to equip them according to a processor's specification. Growers also invest in the development of special skills needed to run their operations efficiently. These assets are considered relationship-specific because their value outside the industry is virtually nil, and their value within the industry, but outside the contract is significantly reduced.

There are two important factors affecting the salvage value of relationship-specific investments in the broiler industry: (1) physical specificity, and (2) location specificity. Housing facilities are valuable assets within a contract with a current processor, whereas outside the contract, they need to be modified to satisfy other processors' specific requirements. Secondly, processors may have monopsony-oligopsony power in a given geographical area in the sense that growers may have limited opportunity to contract with other processors. The fact that live birds cannot be transported over a long distance significantly reduces growers' choice of processors. In this case, location specificity translates into market power.[1]

In both of these situations, the growers' assets are a source of potentially appropriable quasi-rents in the sense that they have low salvage value outside the bilateral contractual relationship.[2] This constitutes a hold-up problem that can manifest itself in two ways. First, according to Williamson (1985), appropriable quasi-rents affect the level of

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[1] Among distinctive structural characteristics of agricultural markets discussed by Rogers and Sexton (1994) the following three pertain to broiler production: (a) agricultural products are perishable, (b) processors' needs for agricultural products are highly specialized, and (c) farmers specialize to supply particular commodities through extensive investment in sunk assets.

[2] Quasi-rents can be measured by the value of the asset in excess of its next best alternative use (Klein, Crawford, and Alchian 1978).

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investments. Being aware of the possibility that they may be held-up by processors, growers will cautiously invest in specific assets. These investments are considered sub-optimal compared to the situation where processors and growers vertically integrate. The magnitude of the under-investment problem varies with factors determining the salvage value of the investment, which in turn affects the magnitude of quasi-rents. Second, after housing facilities have been constructed, the processor may exploit his advantageous bargaining position by frequently requesting upgrades and technological improvements as conditions for contract renewal. Lewin-Solomons (2000) showed that growers may be held up since physical specificity could effectively reduce the grower's compensation without causing additional moral hazard problems. When a contract involves physical asset specificity, the fear of contract termination induces the agent to exert high effort without the need for efficient compensation.

In this article, we construct two tests of hold-up and empirically verify the derived propositions by using the cross-sectional national survey of broiler growers.[3] First, within the incomplete contracts paradigm, we hypothesize the presence of grower under-investment in housing facilities and predict that the degree of under-investment will be related to the number of processors competing for grower services in a given area and to the level of investment specificity. The stronger the competition and the more generic the investments, the smaller the under-investment problem. Second, we provide an indirect test of hold-up by looking at the grower contract payoffs as a function of the frequency of the technology upgrade requests and the processor's market power. Based on the efficiency wage model with asset specificity, we hypothesize that broiler integrators may force excessively high levels of asset specificity onto growers thereby alleviating the need for high efficiency wages.

The results are mixed. When it comes to testing the under-investment model, the results seem to be, at least partially, supportive of the prediction that growers' relationship specific investments depend systematically on processors' market power and the degree of asset specificity. The second prediction that the increase in asset specificity would enable a fall in grower compensation rate was empirically verified only in situations where an integrator was a monopsonist. In other more competitive market structures the hypothesis did not hold.

Contracts and Hold-Up: Theory and Evidence

The economic relationships where hold-up may occur are characterized by the existence of rents to continuing an existing relationship (because of turnover costs or asset specificity) that are available to parties to bargain over, significant problems of writing contracts contingent on all important future events, and the fact that all contracts can be renegotiated by mutual consent (Malcomson 1997, p. 1916). The literature on hold-up originated within *transaction costs (rent-seeking)* theory and its objective of explaining the organization of firms. More recently however, the more formal *incomplete contracts* theory, also known as *property rights* theory has received considerable attention.[4]

The origins of transaction costs theory can be traced back to Coase (1937). Coase focused on the costs of transacting in different organizational environments, particularly, the cost of writing, executing, and enforcing contracts. He argued that an organization is designed to minimize the transaction costs of doing business between parties. Expanding on Coase's ideas, Williamson (1985) argued that economizing on transactions costs is the primary motivation for adopting different structures governing the contractual relationship between parties. For example, if the transactions between two parties (buyer and supplier) are recurrent and involve high levels of specific investment (i.e., idiosyncratic transaction), the two will have a strong incentive to vertically integrate. Signing the contract to govern this relationship may not adequately prevent the hold-up problem from occurring. The reason for this is that it is impossible to stipulate in advance the exact response to all future contingencies (i.e., the complete contract is costly and most of

[3] The survey was conducted by the Indiana Department of Agricultural Statistics and Purdue University and was funded by a grant from the Fund for Rural America; Cooperative State Research, Education, and Extension Service, USDA. We obtained only a portion of the survey responses that were necessary to test the hold-up hypotheses.

[4] According to Gibbons (2004), there are actually four distinguishable theories of the firm; the remaining two being the *incentive system* theory which can be discerned in formal models by Holmstrom and Milgrom (1991, 1994), Holmstrom and Tirole (1991), and Holmstrom (1999); and the *adaptation* theory which can be discerned in informal theoretical arguments by Klein and Murphy (1988, 1997) and Klein (1996, 2000).

the time impossible to write). Specifically, the buyer may renege on the contract by threatening not to buy from the supplier at the specified contract price should some unanticipated event occur. The supplier, who incurred the investment, has no choice but to accept the unfair lower price. Without vertical integration between buyer and supplier, the rational supplier will be reluctant to invest in the first place because of the fear of opportunistic behavior by the buyer.

The Coase–Williamson idea has been widely tested. In particular, the theory of relationship-specific investment and the scope of the firm has been extensively tested in the area of industrial procurement. When firms require specialized inputs that have higher value inside the contractual relationship than in an open market, they must decide if they will produce those inputs themselves or purchase them either on the spot market or by entering a long-term contract. The trade-off between production efficiency and the severity of hold-up governs the choice of length and flexibility of procurement contracts when transactions involve physically specific assets. Joskow (1985, 1987, 1990), Masten (1984), Monteverde and Teece (1982), Levy (1985), John and Weitz (1988), and Maher (1997), all adopt similar research strategies to empirically test the theory. These researchers typically collect the data on contractual forms and measures of physical asset specificity in various contexts. For example, in Joskow's series of articles, the relevant assets are coal mines and power plants. Researchers then show that simple spot markets are used less frequently relative to other organizational forms, such as long-term contracts or vertical integration, when assets are more relationship-specific.

The empirical testing of transactions cost theory suggests that the direct evidence of one party being held-up is rather rare. This is because parties are aware of such problems and have already adopted suitable institutional arrangements to address the problem of expropriation in advance. Without those mechanisms, parties would be reluctant to invest, or their investment level would be sub-optimal. For example, coal mines eventually sign long-term contracts or vertically integrate with electricity firms (Joskow 1987). Similarly, the empirical evidence of hold-up in franchising contracts, which are organizationally very similar to livestock production contracts, appears to be quite rare as well (Beales and Muris 1995).

At the time when empirical work was providing confirmation for transactions cost theory, a closely related and more formal theory of vertical integration emerged in the work of Grossman and Hart (1986), Hart and Moore (1990), and Hart (1995). Like the transactions cost approach, incomplete contracts theory takes the incompleteness of contracts and existence of *ex post* quasi-rents as critical to understanding hold-up. Incomplete contracts theory then focuses on how ownership of physical assets, which confers residual rights of control over these assets, alters the efficiency of trading relationships (Whinston 2003, p. 2).

From the perspective of the hold-up problem, the main point that distinguishes incomplete contract theory from its predecessor seems to be its explicit focus on distortions in *ex ante* investments, in contrast to maladaptation in the contract execution phase emphasized in transaction cost economics.[5] However, incomplete contract theory's focus on *ex ante* investments seems mostly a matter of modeling convenience, since residual rights of control could also affect the efficiency of bargaining. As a matter of fact, the transactions costs literature does recognize that *ex ante* investment distortions are a potential cost of *ex post* opportunism (Whinston 2003, p. 5).

A way to potentially correct the distortions in *ex ante* investments is to introduce the *ex ante* optimal renegotiation mechanism (Hart and Moore 1988; Aghion, Dewatripont, and Rey 1994; Noldeke and Schmidt 1995). The under-investment problem may be solved by allocating all bargaining power in the renegotiation process to one party, and by specifying an appropriate default point that obtains if renegotiation breaks down. For example, in Aghion, Dewatripont, and Rey (1994), the default point is an exogenous value that induces the optimal level of investment decided by the party who has all the bargaining power in the renegotiation process. The results imply that if the default point is correctly guessed, under-investment will not occur. The *ex ante* optimal renegotiation design result is interesting because it corrects the hold-up problem by simply writing a contract with an optimal

[5] As Williamson (2000, p. 605) puts it: "The most consequential difference between the TCE (transaction cost economics) and GHM (Grossman–Hart–Moore) setups is that the former holds that maladaptation in the contract execution interval is the principal source of inefficiency, whereas GHM vaporize *ex post* maladaptation by their assumptions of common knowledge and costless bargaining."

renegotiation clause. However, it is unclear whether renegotiation design can be written *ex ante* in a world of incomplete information.

Stylized Facts and Two Simple Models

The modern broiler industry is a vertically integrated system of production, processing, and distribution. Broiler companies (called integrators) control all stages of production ranging from breeding flocks and hatcheries to broiler grow-out and processing. The finishing stage of production (the final stage of the production process where one-day-old chicks are brought to the farm and grown to market weight) is organized almost entirely through contracts between processors and independent growers. Over the past forty years, the industry has become increasingly concentrated such that in 2002 the industry's five-firm concentration ratio based on the volume of production was 55.41. The largest five firms in the industry are Tyson Foods, Goldkist, Pilgrim's Pride, ConAgra Poultry, and Perdue Farms (WATT Poultry USA 2003).

Broiler companies typically run their operations through smaller divisions (profit centers) spread throughout the country. Each division offers a contract to all prospective growers on a take-it-or-leave-it basis. Contracts usually do not include provisions specifying the number of flocks that a grower will receive per year. In fact, many of them are valid for only one flock of birds at a time. Virtually all contracts stipulate the identical division of responsibilities for providing inputs. The integrator's responsibility is to provide baby chicks, feed, medication, and services of field personnel. Growers are required to construct and equip broiler houses and supply labor and management. They are also responsible for utilities, repair and maintenance, waste, and dead bird disposal.

Total grower investments in the broiler contract business consist of the housing facilities and a variety of other smaller investments necessary to run the business efficiently. Investments in broiler houses and equipment are observable, verifiable, and hence considered to be contractible. Modern broiler houses are well-insulated, environmentally controlled units equipped with automatic feeders and watering lines. A two 20,000 square feet house contract broiler production unit with tunnel ventilation, solid walls, cool pads, infrared brooders and furnaces, and nipple drinkers with capacity of 23,000–27,000 birds per house, costs in the range of $230,000–$260,000 (Cunningham 1998). The functionalities of broiler houses are specific to broiler production such that retrofitting them for other purposes (e.g., growing turkeys) may be prohibitively costly. In addition to investing in chicken houses, growers invest in their own education, training, and mastery of various special skills (disease detection, culling of sick birds, biosecurity practices, feed management, waste management, etc.), and they also invest in other pieces of equipment and machinery that are not exclusively used for the chicken contract operation but are rather shared with other enterprises on the farm (front-end loader, tractor, manure spreader, etc.). All these investments are hard to observe by the integrator and would be even harder to verify by the courts, hence they are deemed noncontractible.

The nature of broiler production prescribes some optimal (maximal) farm size. The optimal number of chicken houses per farm most likely varies with climate, technology, and other systematic differences across regions, bird sizes, and firms (integrators). From the data we can see that the average number of houses per farm is 3.6 with a tight standard deviation of 1.89. The main reason for why we do not see very large contract broiler farms is biosecurity. This is also one of the principal reasons as to why contracting with independent farmers, rather than company owned farms, became the exclusive mode of organizing broiler production. The integrators are reluctant to place a large number of birds on the same farm because they fear outbreaks of epidemic diseases, such as *avian influenza*, that are quite frequent in this industry. In case a disease strikes a particular farm, the entire flock on that farm will be destroyed, but complete isolation of that farm will hopefully prevent a disease from spreading to other farms, and chances are that damages may be contained.

On the other hand, the objective of minimizing costs requires some geographical concentration of production units. Contract growers are typically located within a short distance from the integrator's processing plant because live birds cannot be hauled long distances. Broiler operations also tend to be concentrated in the proximity of feed mills such that integrator's costs of distributing feed to contract producers are minimized. These characteristics are very important because they restrict the grower's choice of integrators. We anticipate that the location specificity of growers' assets, and therefore, their salvage value will be different in different areas. In an area where there are many integrators, grower's assets will have a relatively high salvage value because the same assets can be utilized to produce broilers under contracts offered by another company. On the contrary, grower's assets will have relatively low salvage value in areas where the number of integrators is small.

When contracts are up for renewal, which implicitly happens whenever a new flock of birds is delivered to the farm, the bargaining power of the grower can be substantially diminished, depending on the degree of asset specificity. The integrator may exploit this situation by not changing the nominal payment to growers for many flocks even if the period has experienced significant cost inflation. Alternatively, the integrator may require frequent upgrades of facilities and equipment without necessarily making adequate provisions in the contract that will secure the grower's market rate of return on this additional investment.[6] Growers' complaints about these types of opportunistic behavior by integrators have been documented in Ilvento and Watson (1998) and Farmer's Legal Action Group (2001).

Under-Investment Model

We model a contractual relationship between two risk-neutral parties: a broiler processor (integrator) and a contract broiler grower. We assume that grower investments in broiler contract production can be measured in units of I, such that the value of total investment is given by cI, with c representing the marginal (and average) cost of investment. The benefits from the stream of services generated by the grower's investment is a function of the investment, $b(I)$, with $\frac{\partial b(I)}{\partial I} > 0$, and $\frac{\partial^2 b(I)}{\partial I^2} < 0$. The contract stipulates that the processor compensates the grower for his services, after which she becomes the residual claimant on the realized benefits.

Consider first the efficient level of investment. Because the grower's compensation appears on the revenue side for the grower and on the cost side for the processor, it drops out entirely, and the first-best outcome is obtained by solving $\max_I \Pi = b(I) - cI$, which yields $\frac{\partial b(I)}{\partial I} = c$. As usual, the efficient level of investment is obtained by equating the marginal benefit of investment with the marginal cost of investment.

Next, denote by $r(n, \lambda, I)$ the value of the grower's investment outside the contractual relationship (i.e., the salvage value). This value depends on the size of investment, I, the degree of the investment's physical specificity, $\lambda \in [0, 1]$, and the degree of location specificity determined by the number of processors in the area, $n \geq 1$. The most extreme form of physical specificity (i.e., the investment is useless outside the current contract) is given by $\lambda = 0$, whereas $\lambda = 1$ means that the investment is generic. We assume a differentiable form of the salvage value function

$$(1) \qquad r(n, \lambda, I) = \lambda I \left(1 - \frac{1}{n}\right)$$

such that in case of the extreme physical specificity, the salvage value $r(n, 0, I) = 0$ regardless of the number of processors in the area, and in case of perfect monopsony, the salvage value $r(1, \lambda, I) = 0$, indicating that the investment has no value outside the current contract regardless of its physical specificity. Of course, $r(n, \lambda, 0) = 0$. In addition, $\frac{\partial r}{\partial n} = \frac{\lambda I}{n^2} \geq 0$, meaning that higher concentration of processors translates into higher salvage value of the investment, and $\frac{\partial r}{\partial I} = \lambda(1 - \frac{1}{n}) \geq 0$, meaning that the higher the investment, the higher the salvage value outside the contractual relationship. Finally, $\frac{\partial^2 r}{\partial I \partial n} = \frac{\lambda}{n^2} > 0$, indicating that the cross-partial derivative of the salvage value function is positive and symmetric. The increment in the salvage value increases when the number of processors in the area increases.

For completeness, one also needs to specify the default payoff for the processor when no contracting takes place. Since the processor is assumed to make no investments, the value of her investment outside the contract is naturally zero. Therefore, the total gain from contracting is $b(I) - r(n, \lambda, I)$ because the cost of investment has already been incurred and is thus sunk, and the grower's compensation drops out. The gain from contracting is presumed positive. If it is negative, continued contracting is inefficient and the parties simply go their separate ways.

Now suppose that the parties engage in Nash bargaining (Hart and Holmstrom 1985) over the distribution of gains from contracting. In

[6] For example, an integrator may ask growers to convert their chicken houses from the standard *curtain* ventilation to the more efficient *tunnel* ventilation. If there are no other integrators in the area, growers will have limited alternatives aside from upgrading their facilities, whereas in the areas with multiple integrators offering contracts, some growers may refuse to upgrade and instead move to another integrator that does not use tunnel ventilation on her contract farms.

particular, the parties bargain to determine the compensation that the grower will receive for his services p. Suppose that bargaining enables the grower to capture a share $\alpha \in [0, 1]$ of this gain. Then, the bargained compensation is

$$(2) \qquad p^* = r(n, \lambda, I) + \alpha[b(I) - r(n, \lambda, I)]$$

which clearly increases with the size of investment. The processor thus captures part of the return on the grower's investment, which is exactly Williamson's (1985) hold-up.

Anticipation of hold-up affects the grower's choice of investment as his decision to invest is determined by the solution to $\max_I \pi = p^* - cI$, or more precisely:

$$(3) \qquad \max_I \pi = \alpha b(I) + (1 - \alpha)\left[\lambda I \left(1 - \frac{1}{n}\right)\right] - cI.$$

For simplicity we assume that the parties have equal bargaining power such that $\alpha = \frac{1}{2}$ and they split the benefits evenly.[7] The first-order condition now becomes

$$(4) \qquad \frac{1}{2}\left[\frac{\partial b(I)}{\partial I} + \lambda\left(1 - \frac{1}{n}\right)\right] - c = 0$$

and the second-order condition for maximization is automatically satisfied since $b(I)$ is a concave function. With decreasing marginal benefits from investing ($\frac{\partial^2 b(I)}{\partial I^2} < 0$), the investment level that satisfies (4) will always be lower than the first-best level of investment given by $\frac{\partial b(I)}{\partial I} = c$. This is because $2c - \lambda(1 - \frac{1}{n}) > c$ for any meaningful cost value (i.e., for $c > 1$). Therefore, if the processor has any bargaining power at all, the grower will always underinvest.

The comparative statics results based on (4) show that

$$(5) \qquad \frac{\partial I^*}{\partial n} = -\frac{\frac{\lambda}{n^2}}{\frac{1}{2}\left(\frac{\partial^2 b(I)}{\partial I^2}\right)} \geq 0$$

and

$$(6) \qquad \frac{\partial I^*}{\partial \lambda} = -\frac{\left(1 - \frac{1}{n}\right)}{\frac{1}{2}\left(\frac{\partial^2 b(I)}{\partial I^2}\right)} \geq 0.$$

The signs of both comparative statics results are non-negative because the denominator in both expressions is negative since $\frac{\partial^2 b(I)}{\partial I^2} < 0$. The results indicate that the smaller oligopsony power (more processors) and lower physical asset specificity both lead to larger investment in relationship specific assets. Also, based on Young's Theorem, the cross-partial derivatives are the same, i.e.,

$$(7) \qquad \frac{\partial^2 I^*}{\partial n \partial \lambda} = \frac{\partial^2 I^*}{\partial \lambda \partial n} = -\frac{\frac{1}{n^2}}{\frac{1}{2}\left(\frac{\partial^2 b(I)}{\partial I^2}\right)} \geq 0$$

and nonnegative, which indicates that the marginal reduction in equilibrium investment under hold-up caused by increased market power is amplified by increased asset specificity, and that the marginal reduction in equilibrium investment caused by increased asset specificity is amplified by the integrator's market power.

Efficiency Wage with Asset Specificity

Our second approach to the hold-up problem in broiler contracts is motivated by Lewin-Solomons (2000). Critical of direct tests for hold-up, she argues that the reason for why we rarely observe hold-up is because it only occurs off the equilibrium path but nevertheless influences equilibrium payoffs.[8] The reason for weak empirical evidence of actual hold-up (excessive opportunism) is because parties will always seek contracts that prevent such opportunism, since opportunism reduces total surplus and hence is good for no one. The crux of the problem is the fact that the potential for opportunism can have a significant influence on contract stipulations even if no actual opportunism occurs. The mere fact that the integrator could act opportunistically helps in keeping growers in check. Therefore, in testing for the presence of hold-up, it is not valid to look only for actual instances (Lewin-Solomons 2000, p. 10).

The above argument is rooted in the standard efficiency wage result (Shapiro and Stiglitz 1984). Namely, when incentive problems (caused by the grower's limited liability and the moral hazard problem associated with the fact that effort is unobservable) are sufficiently severe, growers earn positive employment rents. If these rents are high enough, integrators may hire fewer growers, which would result in involuntary unemployment for

[7] The comparative statics results derived below continue to have the same signs for any bargaining share $\alpha \in (0, 1)$.

[8] Most of her critical remarks focus on the literature on regulation of franchising contracts (Beales and Muris 1995; Brickley, Dark, and Weisbach 1991), which are in many respects similar to the broiler industry integrator-grower contracts.

some growers who are perfectly willing to sign a contract but are not able to obtain one. The presence of involuntary unemployment creates an additional incentive for the grower to exert high effort because shirking increases the probability of getting fired. Because grower utility from shirking (exerting low effort) is now lower than before, the incentive compatibility constraint can be satisfied with a lower wage relative to the situation where the market clears.

Next, we add asset specificity. In this case, compensation has to be high enough that the grower has sufficient incentive not to shirk and that he earns sufficient quasi-rents to justify the entire investment. Enforcing high effort now becomes cheaper because a grower fears that, if terminated, he may loose part of the investment that is relationship-specific. The minimum incentive-compatible wage is therefore lower than without asset specificity and the need for involuntary unemployment is reduced since termination is costly even with full employment. The threat of having to switch to another integrator may replace the threat of unemployment. In fact, as shown by Lewin-Solomons (2000, p. 21) involuntary unemployment may not exist at all, in which case any form of anti-termination regulation cannot be justified purely on efficiency grounds.

However, when markets fail to clear (which happens when the minimal incentive-compatible wage with full employment is above the reservation level and demand at that wage is insufficient to employ all growers), distortions will exist because integrators can reduce the necessary wage by requiring excessively high levels of asset specificity. When an integrator is a monopsonist, this effect is amplified because an increase in the grower's compensation will cause a smaller increase in the grower's incentive to exert high effort than in the competitive case. This is because by increasing her grower's pay the integrator has increased the market wage and therefore the grower's termination payoff. Since an increase in asset specificity strengthens the incentive compatibility constraint as much as before, and the fall in grower compensation weakens the constraint less than before, a rise in asset specificity makes possible a larger fall in grower compensation relative to the competitive case.[9]

[9] This effect on the termination payoff is ignored by the competitive firm but internalized by a monopsonist. This result is proved formally as Proposition 2 in Lewin-Solomons (2000, pp. 23–24).

Empirical Investigation

The data set used in this study contains the results of the survey of contract growers that produced broilers for different integrators in mid to late 1999 in Alabama, Arkansas, Delaware, Georgia, Maryland, Mississippi, North Carolina, South Carolina, Texas, and Virginia. The data set has 983 partially usable observations containing information on the individual grower's socioeconomic characteristics, investment in broiler operation (number, size, and age of the chicken houses), performance and overall satisfaction with contracts, and the degree of local competition for grower services among integrators.

The average contract broiler grower is fifty-one years old, has a high school education, and sixteen years of experience as a broiler grower. Almost 82% of the contract holders are males. For 86% of growers, the broiler enterprise accounts for more than a half of their gross farm income. For 47% of growers, more than a half of the previous year's total family income came from chickens. Other sources of income for a large number of contract broiler growers is off-farm employment. The average contract broiler farm holds 0.77 off-farm jobs. The indebtedness of contract growers is significant. Only 27% of growers had total farm debt below $50,000 at the end of 1998. However, about 85% of them had total farm debt of less than half a million dollars. For nearly 47% of growers, more than three quarters of the total farm debt is tied to broiler operation. This is not surprising in light of the fact that construction of chicken houses, necessary to obtain a production contract with an integrator, is typically financed by mortgage type loans.

The average contract farm's investment consists of 3.6 chicken houses, where 76.6% of the farms in the data set have between one and four houses, whereas 93.4% of farms have less than six houses. Chicken houses vary in terms of floor space, ranging from 4,000 to 26,000 square feet per house. The variation in size for older houses is more pronounced, while newer facilities tend to be more standardized. The age of housing facilities varies dramatically from farm to farm. Some houses are brand new and others are more than sixty years old. The average house in the data set is 14.6 years old. The number of substantial improvements made to each house varies substantially across houses between zero and thirteen, with the average number of improvements of 2.5 per house.[10] The variation is of course greater if one draws a comparison across farms. The average number of improvements per farm is 5.1, with the standard deviation of 6.8, the minimum of zero, and the maximum of 63.

Many among the surveyed contract growers report bad financial results. Approximately 8% of the growers claim that they lost money in 1998, whereas 32% report an annual net cash flow below $15,000. Given that virtually all broiler contracts use variable piece rates to compensate growers, grower annual income is highly sensitive to the number of flocks grown each year, the total weight of harvested broilers, and the grower's efficiency in utilizing feed and other integrator supplied inputs.[11] During the three-year period prior to the survey, each grower had received on average 5.5 flocks per year and the average grow-out weight was 5.1 pounds per bird. The individual grower performance variable indicates that the average grower in the data set ranked above the average of his/her settlement group approximately six out of ten times indicating that the average grower in the data set may be slightly better than the average grower in the population of contract growers. However, given the standard deviation of 2.72, the difference is not significant.[12]

Several questions in the survey provide information about the growers' overall satisfaction with the contract. Only 60% of the surveyed growers reported that in the last three years the contract had changed to increase their net pay. Almost 41% responded that their income from broiler operation had been less than they expected based on the information they had received from the company when they were starting out. Among the reasons that explain lower than expected income, in the first place growers mention operating costs that had risen faster than expected, followed by the poor quality of chicks received from the integrator, the company's frequent requests for expensive improvements and upgrades, and higher than expected chick mortality.[13]

Finally, critical for answering the research questions formulated in this article are the survey responses related to industry concentration and local competition for grower services.[14] The results show that the average number of integrators offering contracts in a grower's area at the time of the survey was 2.48, down from 2.8 in the period when the grower first started growing broilers. Approximately 29% of growers had only one integrator to contract with when they started contracting. The situation did not change much over time. At the time of the survey, about 28% of growers still had only one integrator offering contracts in their area. The summary statistics of the variables used in estimation of the econometric models are reported in table 1.

Testing for Under-Investment

From the previously derived theoretical results, it follows that grower investment varies positively with n and λ, which jointly determine the salvage value of the investment. Specifically, based on (5), it follows that keeping physical specificity (λ) constant, in equilibrium, growers facing less competition among integrators would tend to under-invest in a contract relationship with an integrator. In other words, for any given level of physical specificity of the investment, the size of the investment is explained by its location specificity where the latter is measured by the degree of competition among the integrators offering contracts. This result can be summarized as follows:

PROPOSITION 1. *The size of the grower investment is positively related to the number of*

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[10] The survey question asks for substantial improvements made to each house over past five years, whereas "substantial" means improvements costing at least $3,000 each.

[11] The majority of broiler contracts are settled using a two-part piece-rate tournament consisting of a base payment per pound of live meat produced and a bonus payment based on the grower's relative performance. The bonus payment is calculated as a percentage of the difference between group average settlement cost and grower's individual settlement cost. Settlement cost for each grower is the sum of the costs of integrator supplied inputs (chicks, feed, medication, etc.) divided by the total pounds of live broilers produced. The calculation of the group average settlement cost includes growers whose flocks were harvested within the same week. For the below average settlement cost, the grower receives a bonus; for the above average settlement cost, he receives a penalty. For detailed description of broiler tournaments see for example Knoeber and Thurman (1994), Tsoulouhas and Vukina (2001), and Levy and Vukina (2004).

[12] Tournaments work such that one half of the participants receives the bonus and the other half receives the penalty. Aggregate bonus and aggregate penalty cancel each other out precisely. Therefore, in a sequence of ten tournaments, an average ability grower should win five and lose five tournaments.

[13] The problem of asymmetric distribution of variable quality inputs by integrators to growers of different abilities has been studied by Leegomonchai and Vukina (2005). They tested for the presence of career concerns and ratchet effect type of dynamic incentives in broiler contracts and found little empirical evidence of integrators's discrimination.

[14] The exact survey questions are: "When you started growing broilers, how many companies were offering broiler contracts in your area?" and "How many companies are currently offering broiler contracts in your area?" The answers are subjective, but this is not a problem because the individual growers' perceptions are what matters for investment decisions and not the actual numbers.

Table 1. Data Summary Statistics

Definition	Obs.	Mean	Std. Dev.	Min	Max
Number of houses each grower operated in 1999	983	3.6	1.89	1	12
Total size of all houses on a farm (in sq. ft.)	983	57,014	33,000.62	6,720	197,000
Number of improvements per farm	983	5.1	6.79	0	63
Size of the individual house (in sq. ft.)	3,564	15,725	3,735.78	4,000	26,000
Vintage of the individual house	3,563	14.6	9.94	1	65
Number of improvements per house	1,984	2.5	1.82	1	13
Number of houses each grower had when started	829	2.7	1.51	1	12
Size of all houses each grower had when started (in sq. ft.)	829	41,296	26,062.78	4,000	164,600
Number of integrators offering contracts in 1999	821	2.48	1.49	1	11
Integrators offering contracts when grower started	828	2.81	2.25	1	20
Years of past experience as broiler grower	971	16.1	10.18	1	61
Grower's age in 1999	975	51	10.93	17	84
Over past 10 flocks ranked better than average	802	5.96	2.72	0	10
Average number of flocks per year in 1996–1999	973	5.52	0.74	3	8.5
Average number of of birds placed per flock in 1996–1999	964	71,947	41,549.93	12,000	300,000
Average weight per bird (in pounds) in 1996–1999	949	5.13	1.17	1.95	8.4
		Percent	–	–	–
Contract changed to increase net pay in 1996–1999	915	59.89			
Growers with 1998 net cash flow negative	983	0.08			
Growers with 1998 net cash flow $0–$14,999	983	0.325			
Growers with 1998 net cash flow $15,000–$29,999	983	0.275			
Growers with 1998 net cash flow $30,000–$44,999	983	0.153			
Growers with 1998 net cash flow $45,000–$59,999	983	0.042			
Growers with 1998 net cash flow $60,000+	983	0.036			

Source: "Broiler Growers' Survey." Indiana Dept. of Ag. Statistics and Purdue Univ., Aug. 1999.

integrators contracting for grower services in a given area.

A possible criticism of this approach is the argument that equation (5) could just as easily be interpreted as a result of imperfect competition and not incomplete contracting.[15] What makes Proposition 1 a valid test of hold-up are the technological characteristics of broiler production. As mentioned before, the nature of broiler production prescribes some optimal (maximal) farm size. Therefore, an increase in competition for grower services in a given area is likely to increase the number of farms with contracts and not necessarily the number of chicken houses on existing contract farms. The increase in the number of chicken houses on existing farms can only happen if the previous number of chicken houses was suboptimal as predicted by the under-investment model.

Given the available data, the only approach to testing Proposition 1 is to approximate the size of the grower total investment with its contractible component, i.e., with the investment in chicken houses. Of course, total grower investment is larger than investment in chicken houses alone, but it seems reasonable to assume that the decision to invest in the noncontractible part is guided by similar considerations to investment in the contractible part. Therefore, we measure the investment of grower i as the number of the chicken houses initially constructed I_i^0 and relate that quantity to the number of integrators n_i^0 that were offering contracts at the time period when that grower started out as a broiler grower. For that purpose, we specify the following econometric model:

$$(8) \qquad I_i^0 = \alpha_0 + \alpha_1 n_i^0 + \alpha_2 \mathbf{z_i} + \sum_{k=2}^{10} \delta_k s_i^k + \sum_{t=2}^{T} \rho_t d_i^t + \epsilon_i$$

where $\mathbf{z_i}$ is the vector of the grower's socio-economic characteristics, δ_k is the investment shock common to all farmers that reside in the same state k, ρ_t is the investment shock

[15] We owe this point to two anonymous referees. As one of them writes: "A possible alterative to hold-up is that, even in the absence of hold-up or opportunism, simple intuition tells me that growers may increase investments if there are lots of chicken processors around."

common to all growers who started out is broiler growers in the same year t, $s_i^k = 1$ if $i = k$ and 0 otherwise, and $d_i^t = 1$ if $i = t$ and 0 otherwise. Finally, ϵ_i is an individual farmer's idiosyncratic investment shock. Proposition 1 will be supported by the data if the sign of α_1 is positive and statistically significant.

The initial investment variable I_i^0 was constructed by combining responses to the question about the number of years a farmer had been a broiler grower with responses to the question about the number and age of houses that each grower operates. The data contain three cases. The simplest case is where the number of years that a grower spent as a broiler grower exactly equals the age of the oldest chicken house on the farm. In this case, the initial investment is measured by the number of chicken houses of the same oldest age. The second case is where the number of years that a grower spent as a broiler grower is less than the age of the oldest house on the farm. This case describes a situation where a grower bought (or perhaps inherited) an existing broiler farm. The initial investment in this case is determined by the number of houses whose age is greater or equal to the years of farmer's experience as a broiler grower. All houses that satisfy this criterion can be treated as initial investment because, arguably, a grower must have bought the operation of the size he thought was appropriate given the integrator's market power. Finally, the number of years that a farmer had been a broiler grower can be larger than the age of the oldest chicken house on the farm. This case is likely reflective of a situation where a grower started out long time ago and already decommissioned some of the oldest houses on the farm, or perhaps even sold the old facility and moved to a new location. Given how survey questions were phrased (see footnote 14), there is no good way of determining the size of the initial investment in this case. Lacking better solution, this problem will be addressed by dropping the data that fit into this category and re-estimating the model to see whether the results change.

There are different ways to measure market power of the integrator n_i^0. One approach would be to simply use the number of integrators as a continuous variable. In this case, adding an additional integrator would have the same (constant) effect on grower investment decisions regardless of the existing number of integrators operating in his area. However, this may not be realistic because a grower contemplating investment might be very concerned if there is only one integrator in the area, may still be somewhat concerned if there are two or three, but would not care about an additional integrator if there are already five or six of them offering contracts in his area.[16] To address this problem we introduce separate indicator variables corresponding to different market structures: monopsony (1 integrator), duopsony (2–3 integrators), oligopsony (4–5 integrators), and perfect competition (6 or more integrators).

Among growers' socioeconomic characteristics we include only purely exogenous variables such as growers' sex, age, and education. The age variable measures a grower's age when he started growing broilers and is obtained by subtracting the years of experience as a broiler grower from the grower's age at the time of the survey. Variables such as income, debt, etc., can be interpreted as consequences of investment decisions that farmers previously made and are, therefore, endogenous. Time dummies are included in the model to absorb the impact that the business cycle might have had on growers' investments. Particularly important is the dynamics of broiler industry costs and returns and its ramifications for the entry and exit of broiler companies.

The estimation results are presented in table 2. They show the estimation results obtained by excluding the observations where the number of years that a farmer had been a broiler grower is larger than the age of the oldest chicken house on the farm.[17] The left-hand side panel shows the OLS estimates of two models: with, and without the state fixed effects. In the model that includes state fixed effects the monopsony variable is negative as expected and is statistically significant. It indicates that the average grower investment under monopsony is by 0.5382 houses less then under a perfectly competitive market. Given the fact that the average starting number of houses per farm was 2.7, this effect is economically quite significant.

The market power variables all have correct signs. However, they are not monotonically decreasing as expected, with the duopsony effect being somewhat larger than that of monopsony. The magnitude of the oligopsony

[16] This point was brought to our attention by an anonymous referee. For an application to a similar issue, see MacDonald, Handy, and Plato (2002).

[17] We also estimated the models including all observations and the results were qualitatively identical. Qualitatively similar results were also obtained using the number of integrators as a continuous variable.

Table 2. Estimation of the Under-Investment Model—Proposition 1

	OLS		Poisson	
Number of Houses	Model 1	Model 2	Model 1	Model 2
Intercept	1.9836 (1.34)	8.9028 (6.14)	−0.3921 (−0.39)	−0.1599 (−0.16)
Monopsony	−0.5382 (−2.03)	−0.0081 (−0.04)	−0.1781 (−1.51)	−0.0036 (−0.04)
Duopsony	−0.5447 (−2.12)	−0.1294 (−0.61)	−0.1760 (−1.53)	−0.0485 (−0.51)
Oligopsony	−0.4120 (−1.56)	−0.0129 (−0.05)	−0.1324 (−1.12)	−0.0057 (−0.05)
Grower age	0.009 (1.53)	0.0084 (1.39)	0.0033 (1.28)	0.0029 (1.14)
Male dummy	0.2517 (1.66)	0.2592 (1.69)	0.1062 (1.47)	0.1041 (1.46)
High school dummy	0.0081 (0.04)	0.0792 (0.35)	0.0099 (0.09)	0.0318 (0.30)
Trade school dummy	−0.0313 (−0.12)	0.0819 (0.31)	−0.0003 (−0.00)	0.0349 (0.29)
Some college dummy	−0.0612 (−0.25)	0.094 (0.37)	−0.0135 (−0.12)	0.0408 (0.35)
College & higher dummy	0.5262 (2.05)	0.6491 (2.48)	0.1788 (1.51)	0.2214 (1.89)
States dummies[a]	$F(9{,}628) = 5.35$		$\chi^2(9) = 31.05$	
Time dummies[a]	$F(41{,}628) = 3.93$	$F(41{,}637) = 3.77$	$\chi^2(41) = 101.11$	$\chi^2(41) = 105.26$
R^2	0.2419	0.1953	0.0747	0.0615

[a]States and time fixed effects estimates have been suppressed for brevity. F or χ^2 statistics test that they are jointly equal zero.

Note: Numbers in parentheses are t-statistics in case of OLS regression and Z-statistics in case of Poisson maximum likelihood estimation.

R^2 row represents adjusted R^2 in case of OLS and psuedo R^2 in case of Poisson.

effect is smaller than the first two and the coefficient loses statistical significance. Other coefficients indicate that growers with completed college or higher degree education tend to invest more. State and time dummies are each jointly significantly different from zero.

The obtained results are sensitive to the inclusion of the state fixed effects. As seen from Model 2 results, removing the state fixed effects causes the market power coefficients to become insignificant. Nevertheless, we still believe that the results are supportive of the prediction that grower relationship specific investments vary systematically with processors' market power. The model should include the state fixed effects because of the investment climate in poultry industry that may have been different across states, even if one accounts for the number of processors operating in a given market. For example, it is easy to imagine that access to loans to construct housing facilities could have been easier in some states than others. Also, states may have differed historically with respect to regulation related to the environment or corporate agriculture that could have made the legal climate more or less conducive to investing in contract production. For example, in order to protect contract growers, some states have over the years adopted contract anti-termination statutes (Lewin-Solomons 2000; Tsoulouhas and Vukina 2001) that have made grower investments more secure. Lastly, the quality of information available to potential contract growers provided by the extension service or Farm Bureau could have been different across states as well.

Finally, in the right-hand side columns of table 2 we present the results of the Poisson maximum likelihood estimation of the same two models. This estimation technique can be justified on the grounds that the dependent variable assumes integer values between 1 and 12 chicken houses per individual farm. The results are qualitatively very similar to the OLS results with statistical significance of estimated coefficients somewhat lower than in the OLS case.

In order to further explore the relationship between imperfect competition and incomplete contracting another testable implication can be derived from the property rights model developed before. Based on (6), it follows that keeping the number of integrators in any given area constant, the growers faced with increased asset specificity requirements would tend to under-invest in production contracts with an integrator. Moreover, based on (7), the marginal reduction in equilibrium investment under hold-up caused by increased asset specificity will be more pronounced in areas characterized by low competition for grower services. These results can be summarized as follows:

PROPOSITION 2. *The size of grower investment is negatively related to the degree of investment specificity. The effect is worsened by the the integrator's market power.*

Table 3. Estimation of the Under-Investment Model—Proposition 2

	OLS with State Fixed Effects		OLS without State Fixed Effects	
Number of Houses	Model 1	Model 2	Model 3	Model 4
Intercept	3.6762 (6.06)	4.74 (10.07)	3.2928 (7.52)	3.074 (8.16)
Number of upgrades	0.2744 (1.76)	−0.067 (−1.99)	0.298 (1.88)	−0.0895 (−2.61)
Upgrade × monopsony	−0.3763 (−2.32)		−0.3955 (−2.42)	
Upgrade × duopsony	−0.3713 (−2.30)		−0.4286 (−2.64)	
Upgrade × oligopsony	−0.3149 (−1.90)		−0.3861 (−2.30)	
Grower age	−0.0083 (−1.16)	−0.01 (−1.58)	−0.0073 (−0.99)	−0.0101 (−1.54)
Male dummy	0.3505 (1.78)	0.5017 (2.96)	0.4145 (2.08)	0.5768 (3.34)
High school dummy	0.4766 (1.65)	0.6252 (2.56)	0.5272 (1.80)	0.6612 (2.64)
Trade school dummy	−0.0245 (−0.07)	0.1651 (0.57)	0.0733 (0.23)	0.2734 (0.92)
Some college dummy	0.5978 (1.87)	0.6864 (2.48)	0.7363 (2.27)	0.801 (2.84)
College & higher dummy	0.8422 (2.53)	1.0981 (3.77)	0.9668 (2.85)	1.196 (4.01)
States dummies[a]	$F(9,660) = 5.35$	$F(9,796) = 6.94$		
$\bar{R}^2$	0.0902	0.1052	0.0370	0.0458
$\gamma_1 + \gamma_2$(Monopsony)	−0.1019 (−1.88)		−0.0975 (−1.79)	
$\gamma_1 + \gamma_2$(Duopsony)	−0.0969 (−1.88)		−0.1306 (−2.52)	
$\gamma_1 + \gamma_2$(Oligopsony)	−0.0405 (−0.61)		−0.0881 (−1.31)	

[a]States fixed effects estimates have been suppressed for brevity. *F*-statistics test that they are jointly equal zero.
Note: Numbers in parentheses are *t*-statistics.

Proposition 2 can be tested by estimating the following econometric model:

$$(9) \qquad I_i = \gamma_0 + \gamma_1 a_i + \gamma_2 a_i n_i + \gamma_3 \mathbf{z_i} + \sum_{k=2}^{10} \delta_k s_i^k + u_i.$$

I_i measures the current number of chicken houses on farm i, n_i is an indicator variable that captures the current market structure of the industry (monopsony, duopsony, oligopsony, and perfect competition), a_i measures the degree of asset specificity, and other variables are the same as in (8). The degree of asset specificity is measured by the number of substantial improvements (upgrades) per house over the past five years, which implies the opposite expected signs of its coefficients relative to the signs of the comparative statics results in (6) and (7). This is because in the theoretical model $\lambda \in [0, 1]$ was specified such that the most extreme form of asset specificity was given by $\lambda = 0$, whereas $\lambda = 1$ means that investment was generic, whereas here more upgrade requests means higher asset specificity.

The estimation results of four different versions of (9) are presented in table 3. Models 1 and 2 refer to the OLS results including state fixed effects, and Models 3 and 4 are estimated without the state fixed effects. Models 1 and 3 include the interaction terms $a_i n_i$. Yearly dummies were excluded because the model specifies a contemporaneous relationship (at the time of the survey) between variables in the model. The results for both models are qualitatively very similar.

Testing the first part of Proposition 2 produced mixed results. The postulated negative relationship between grower investments and the degree of asset specificity does not hold in competitive environments where the number of integrators is large because $\frac{\partial I}{\partial a} = \gamma_1 > 0$ in both Models 1 and 3.[18] However, in areas where the number of integrators offering contracts is reasonably small, $\frac{\partial I}{\partial a} = \gamma_1 + \gamma_2$ is negative and significant for monopsony and duopsony and still negative but insignificant for oligopsony. The magnitudes of these effects are economically significant. For example, in the model with the state fixed effects, in areas with one integrator offering contracts, increasing the mandatory upgrades by one request would decrease the size of grower investment by 0.102 chicken houses. In areas where there are two or three integrators, one upgrade request would decrease the size of investment by 0.097 chicken houses. A similar result has been obtained by estimating the version of model (9) without the interaction term (Models 2 and 4). These estimates, which

[18] Notice that the indicator variable for perfect competition ($n \geq 5$) has been dropped from the estimation to avoid perfect collinearity (dummy trap).

are reflective of the average competition for grower services for the entire data set (the average number of integrators is 2.48), strongly support the first part of Proposition 2 because γ_1 turned out to be negative and statistically significant in both versions. For example, in the model with the state fixed effects, increasing the number of mandatory upgrades by one, decreases the size of the grower investment by 0.067 chicken houses.

The second part of Proposition 2 postulating that integrator's market power would strengthen the negative relationship between grower investment and asset specificity seems to be supported by the data. In the model with state fixed effects, all three market power indicators (γ_2 coefficients) are negative and significant and the effect decreases as the number of integrators increases. In the model without the state fixed effects, the magnitudes of the market power effect are similar but they are not monotonically decreasing (the duopsony effect is slightly larger than the monopsony effect).

Indirect Tests of Hold-Up

According to the efficiency wage model with added asset specificity, if the market for grower services does not clear, integrators will force excessively high levels of asset specificity onto growers thereby alleviating the need for high efficiency wages. Monopsony power of the integrator in the market for grower services would strengthen this effect. The model also predicts that in such circumstances growers would enjoy limited or no contractual safeguards against the risk of loosing their investment. There is substantial evidence that the broiler industry, may fit this description. The testable hypothesis can be formalized as follows:

PROPOSITION 3. *Let an individual integrator choose grower compensation $\tilde{p}$ and the level of asset specificity $\tilde{a}$, then the increase in asset specificity enables a fall in the compensation rate, i.e.,* $\frac{\partial \tilde{p}}{\partial \tilde{a}} < 0$. *Moreover, if the integrator has a market power, this affect is amplified, i.e.,* $\frac{\partial^2 \tilde{p}}{\partial \tilde{a} \partial n} < 0$.

Relying on this theoretical result and the available survey data, the post-contractual opportunism of broiler processors can be investigated by looking at the relationship between contract payments, the frequency of housing facilities upgrade requests that processors place on their contract growers, and their local market power. To test Proposition 3, we estimate the following model:

$$(10) \qquad p_i = \beta_0 + \beta_1 a_i + \beta_2 a_i n_i + \beta_3 \mathbf{x_i} + \sum_{k=2}^{10} \delta_k s_i^k + e_i$$

where p_i is the unobserved latent variable representing some measure of contract payoff for grower i, $\mathbf{x_i}$ is the vector of grower or farm specific characteristics that can potentially influence contract payoffs, and other variables are the same as in (9).

The results of two different model estimations are presented in table 4. In the first case, the dependent variable is a discrete choice variable assuming the value of 1 if during the three-year period prior to the survey the terms of the contract had changed to increase grower's pay, and 0 otherwise. Since both the grower remuneration scheme and the frequency of upgrades are to a large extent controlled by the integrator, the asset specificity variable a_i may be endogenous. To assess exogeneity of a_i we add an auxiliary equation $a_i = \eta' \mathbf{Z} + v$ that relates the potentially endogenous variable a_i to a vector of relevant exogenous variables $\mathbf{Z}$.[19] The test is performed by applying the probit maximum likelihood estimator to (10) with OLS residuals $\hat{v}$ from the auxiliary equation as an additional regressor. If the estimated coefficient on $\hat{v}$ turns out insignificant, a_i can be treated as exogenous.

The OLS estimation results for the auxiliary equation for upgrade requests show that none of the market power variables are significant. The significant variables are the measure of grower performance and the vintage of the capital stock. Grower performance is measured by the number of times (out of 10 flocks) the grower placed better than average in his settlement group, and the vintage of capital stock is measured by the average age of chicken houses currently in operation. The rationale for including some measure of grower performance (ability) is the fact that frequency of upgrades may depend on how well or how poorly the grower has recently performed. Less efficient growers may be approached more frequently to upgrade their facilities with new technological improvements

[19] The approach of assessing exogeneity of regressors in probit models is due to Rivers and Vuong (1988); see also Slade (1996) for an application.

Table 4. Estimation of the Efficiency Wage with Asset Specificity Model

	Probit		OLS	Tobit
	Pay Increase	Pay Increase (Aux.)	Upgrades (Aux.)	Net Cash Flow
Intercept	0.6431 (2.01)	1.7108 (0.96)	1.7615 (3.09)	−24,861.28 (−2.55)
Number of upgrades	−0.1731 (−1.38)	−0.8112 (−0.76)		−191.4851 (−0.13)
$\hat{v}$		0.6720 (0.61)		
Monopsony			−0.1001 (−0.25)	
Duopsony			−0.2254 (−0.57)	
Oligopsony			−0.1297 (−0.32)	
Upgrade × monopsony	0.0371 (0.28)	0.0155 (0.12)		−869.6495 (−0.55)
Upgrade × duopsony	0.1419 (1.10)	0.0964 (0.65)		−318.1611 (−0.20)
Upgrade × oligopsony	0.1393 (1.07)	0.1096 (0.80)		−697.1333 (−0.44)
Grower performance	0.0541 (2.79)	0.0205 (0.35)	−0.0509 (−1.94)	1,266.659 (5.50)
House vintage	−0. 0066 (−1.05)	0.0172 (0.43)	0.0356 (4.31)	232.3794 (2.91)
Flocks per year				2,932.384 (2.66)
Birds placed				0.1550 (9.11)
Broiler weight				1,931.541 (2.87)
States dummies[a]	$\chi^2(9) = 24.00$	$\chi^2(9) = 23.82$	F(9,668)=1.31	$\chi^2(9) = 10.50$
Log likelihood	−388.87674	−388.69322	$\bar{R}^2 = 0.0361$	−1,052.076
$\beta_1 + \beta_2$(Monopsony)	−0.1360 (−2.80)			−1,061.135 (−2.10)
$\beta_1 + \beta_2$(Duopsony)	−0.0312 (−0.80)			−509.6462 (−1.11)
$\beta_1 + \beta_2$(Oligopsony)	−0.0338 (−0.77)			−888.6185 (−.157)

[a]States fixed effects estimates have been suppressed for brevity. Chi-square statistics test that they are jointly equal zero.
Note: Numbers in parentheses are *Z*-statistics, except for the OLS regression where they represent *t*-statistics.

then more efficient growers who do well even with the old equipment. The rationale for including the average age of the chicken houses is obvious. Older houses should require more frequent upgrades than newer facilities. Both of those coefficient are significant and have the expected sign.

The auxiliary *pay increase* probit equation includes the OLS residuals $\hat{v}$ from the auxiliary *upgrades* equation. Because the $\hat{v}$ coefficient turned out to be insignificant, simultaneity is not a problem. The other version of the *pay increase* equation without the $\hat{v}$ variable is very similar. The only difference is that here the grower performance coefficient is significant, indicating that the contract may have changed to increase pay only for growers that perform well, whereas average growers or below-average growers may have got no increase, or even worse, their pay could have actually gone down. On the other hand, the house vintage coefficient is not significant, allowing rejection of our hypothesis that the contract might have changed to increase pay only for newer houses or for those with superior equipment.

Based on the probit *pay increase* equation, it seems that the postulated negative relationship between the increase in grower pay and the degree of asset specificity does not hold in a competitive environment (where all three market power indicator variables equal 0) because $\beta_1 < 0$ is insignificant.[20] However, in areas where there is only one integrator offering contracts, the first part of Proposition 3 is confirmed because the Wald test shows that $\frac{\partial p}{\partial a} = \beta_1 + \beta_2$ for monopsony is negative and significant. The results are statistically insignificant for duopsony and oligopsony. The second part of Proposition 3 postulating that the integrator's market power would strengthen the negative relationship between the increase in grower compensation and asset specificity is definitely not supported by the data. All three market power indicators (β_2 coefficients) are insignificant and have unexpected signs.

In the second model, contract payoffs are measured as net cash flow from broiler production in the year prior to the survey. According to the questionnaire, *net cash flow* is defined as poultry income left over after paying poultry-related expenses, such as poultry house mortgage payments, insurance, repairs, utilities, and disposal of litter. As seen from table 1, net cash flow variable comes in 6

[20] The magnitude of the coefficient $\beta_1 = -0.1731$ is however sensible. It means that a small increase in the number of upgrades (from the mean value of 1.5) decreases the likelihood that a grower will get a pay raise by 0.0645.

intervals and the model was therefore estimated using Tobit with interval coded data.[21] In addition to grower performance and capital vintage variables, we included the average number of flocks placed on each grower's farm per year during the three-year period prior to the survey, the average number of birds per flock, and the average weight of grown birds. The parameters of all these variables have the expected signs and are statistically significant. Given the nature of the payment formula used to settle broiler contracts it is not surprising that these variables critically influence grower revenue and net cash flow.

As seen from the last column of table 4, all results are qualitatively the same as those obtained by the probit model. The only difference is that the interaction coefficients (slope dummies) between upgrade requests and market power indicators are negative as expected but still statistically insignificant and not monotonic, so the second part of Proposition 3 does not hold. The only hypothesis confirmed by the data is the negative relationship between grower net cash flow and the degree of asset specificity in situations where there is only one integrator offering contracts in a grower's area.

Conclusions

The ideas of hold-up and post-contractual opportunism figure prominently in the theoretical literature, yet the empirical confirmation of these phenomena is hard to produce. In this article, we look for empirical evidence of hold-up in the broiler industry. The main motivation for this endeavor came from the substantial anecdotal and other nonscientific evidence (trade magazines, small farm advocacy groups, etc.) of contract growers complaining about unfair treatment and exploitation by poultry integrators. Given the fact that existing business between processors and contract growers is governed by short-term contracts whereas the underlying relationship is inherently long-term due to the specificity of investments involved in the production of birds, the claim that growers could be held-up by processors deserves to be carefully studied.

In the first part of the article, we considered the problem of hold-up as an under-investment problem. The theoretical rationale for this approach can be found in the property rights (incomplete contracting) theory of the firm. In this case, we expect to observe parties undertaking precautionary measures to prevent hold-up from occurring. Such actions could result in a suboptimal level of investment compared to the first best. We empirically tested two hypotheses using the cross-sectional national survey data of contract broiler growers. We found some evidence of a systematic relationship between the number of processors in a given area and the size of grower investment as measured by the number of chicken houses under contract. Second, we also found that growers tend to invest less in situations where asset specificity requirements tend to be high but only in markets where the number of integrators offering contracts is small.

In the second part of the article, we performed an additional test of hold-up based on Lewin-Solomons (2000). She predicts that when the market for grower services does not clear, which may be the case in some regions of the Southeast where not all prospective broiler growers can find contracts, integrators will force excessively high levels of asset specificity onto growers. This may be manifested in the frequent request for upgrades of existing housing facilities and equipment. We test this proposition by looking at the relationship between grower payoffs and the number of upgrade requests and integrators' market power. The results seem to support the hypothesis that the increase in asset specificity enables a fall in grower compensation rates, but only in monopsonistic environments. We found no evidence of such behavior under competitive or oligopsonistic market structures.

Finally, what can be learned from what appear to be ambiguous results? Before jumping to conclusions, one should admit the limitations of the available data. The survey instrument that produced the data set that we used was primarily designed for a sociologically oriented research agenda. This is why the survey responses required substantial manipulation and creativity to make them usable for the purposes of estimating even the simplest of hold-up models. However, the inconclusiveness of the results cannot be solely blamed on the data. Obviously, there are many microeconomic and econometric issues surrounding this topic that need to be resolved before more definitive answers can be provided. We feel reasonably comfortable claiming that we have provided enough evidence about the presence of the hold-up problem in the broiler industry

[21] The STATA routine that performs this type of estimation is called *interval regression*.

to justify further research in this interesting and complex area.

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