# Production Contracts and Farm Business Growth and Survival

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*Abstract*. In recent decades there has been a substantial increase in the scale of production and the use of production contracts in the hog sector. This paper explores empirically whether these two phenomena are related by examining whether the use of production contracts has allowed finish hog operations to expand in scale. The study takes advantage of recently collected information from the Census of Agriculture that permits a comparisons of individual independent and contract hog producers over time. The study first examines whether operations that used a contract grew at a faster rate or had lower exit rates over the subsequent five-year period than did operations that produced independently, controlling for observable factors. The study then examines how the adoption of a production contract affected subsequent farm size growth. To address the potential endogeneity of contract adoption, the availability of contracting is used as an instrumental variable. The instrumental variable approach makes it credible to assert that the association between contract adoption and growth is a causal relationship.

*Key words*: production contracts, farm structure, farm business exit rate, instrumental variables, hogs.

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## Introduction

In recent years there has been a dramatic growth in the scale of production and the use of production contracts in the hog industry. Between 1992 and 2004 the number of U.S. hog farms declined over 70%, from 240,700 to 69,500, while the hog inventory remained relatively stable (USDA, 2005). Over this period, farms with at least 2,000 head increased their share of the total swine inventory from 28% to 79% (USDA, 2005). This increasing concentration of production was accompanied by a rapid growth in contracting: the share of hogs grown and marketed under a production contract rose from about 5% in 1992, to 40% in 1998, and to 67% in 2004 (Key and McBride, 2007).

The increasing use of production contracts and the growth in the scale of hog farms have increased economic efficiency and provided other benefits for growers and processors. However, these structural changes have also been controversial. The shift to contract production has spurred legislative initiatives and legal challenges aimed at protecting contract farmers from unfair contract provisions and providing them with information about contract terms. There have also been numerous legislative and legal efforts to curb problems with odor, water and air pollution, and to protect animal welfare on large-scale hog operations. While a connection between production contracts and increasing concentration is often assumed or implied, the connection between the two is not well understood nor tested empirically. This study uses Census of Agriculture data for individual hog farms to examine whether production contracts have allowed individual operations to expand and achieve a larger scale of production, thereby contributing to the increasing concentration of production in the hog sector.

There are three fundamental ways by which the use production contracts could increase the average scale of production in a sector. First, if contractors select larger operations with whom to contract, then an expansion in the use of production contracts by packers (motivated, perhaps, by need to regulate the flow of raw product into processing facilities) would result in an increasing scale of production, even if contracting had no direct effect on operator profits or investment decisions. The second possibility is that contracts provide advantages (e.g. access to capital) to operators that allow them to initiate production at a larger size than they would have under an independent organizational arrangement. The third possibility is that production contracts provide advantages to operators (e.g., income risk reduction) that allow them to survive

longer and grow faster than they would have otherwise. In this study, we focus on the second and third possibilities by examining how contract use and adoption influence the scale and survival of individual operations over time.

There are several possible mechanisms by which production contracts could influence farm structure (Key, 2004). Production contracts shift most income risk from growers to contractors (Johnson and Foster, 1994; Knoeber and Thurman, 1995; Martin, 1997). Because contracts lower risk, lenders are generally more willing to approve loan requests or offer lower interest rates to operators with contracts (Barry, 1997). With greater access to credit, growers can invest more in productive capital and thereby achieve greater scale (Boehlje and Ray, 1999). In addition, because they are insulated from most input and output price risk, contract growers may be able to weather market downturns and survive longer than independent operators.

Production contracts may also permit an operation to achieve a larger scale by reducing operators' financing requirements for variable inputs. Under a production contract to finish hogs, the feed and other inputs supplied by a contractor represents, on average, over 80% of the total costs of production (McBride and Key, 2003). Hence, growers who are constrained in their access to financing could achieve a larger scale by producing under contract than independently.

Contracts can also serve to overcome problems of hold-up allowing for greater investment in specific assets and, hence, a larger scale of production. Specific assets are those having physical characteristics tailored to a particular purchaser. Specialized equipment required for hog production, such as manure storage facilities, manure handling equipment, hog barn facilities and equipment, etc., have little value outside of hog production. When there are a limited number of purchasers in a region, farmers who have made costly investments in specific assets are vulnerable to "hold-up": purchasers can lower the offer price, driving farmers toward their reservation price. Long-term contracts can overcome the market failure resulting from asset specificity by guaranteeing a market and price for farmers' output, and thereby encourage more investment in specific physical assets, resulting in a larger scale of production.

Finally, contracting may facilitate technological changes that increase the scale at which average costs are minimized. There is evidence that production contracts enhance farm productivity, perhaps by providing access to managerial expertise and high quality proprietary inputs - such as feed and genetic stock – that are not available to independent producers (Key

and McBride, 2003, 2008). It is plausible that productivity gains increase the optimal scale of production and promote the growth in farm size.

This study uses Census of Agriculture data for individual hog farms to examine whether and how contracting is associated with farm size growth and survival. The 2002 and 2007 Censuses provide information on production and contract use, and permit the tracking of individual operations over time. First, we examine how initial contract status affects subsequent farm growth and survival. That is, we determine whether operations that contracted in 2002 grew at a faster rate or had lower exit rates over the subsequent five-year period than did operations that produced independently in 2002, controlling for observable factors.

Next, we examine how an operator's *adoption* of a production contract affects farm size growth. Specifically we compare the growth rate of hog farms that were producing independently in 2002 and who began to contract between 2002 and 2007 to the growth rates of farms that continued to produce independently over this period, controlling for observable characteristics. A potential problem with this approach is that unobservable factors associated with the decision to contract are also associated with farm size growth. For example, operators with good credit histories may be able to obtain sufficient funding to grow and thereby obtain a production contract. Operators with poor credit scores might not be able to expand and obtain a contract. Hence, we would observe a correlation between farm size and contracting that results because of operators' credit history, and not because of the influence of contracting on access to credit, or other advantages flowing from the use of a production contract.

To address this potential endogeneity problem, we use the availability of contracting as an instrumental variable for contract adoption. The instrumental variable method makes it credible to assert that the association between contract adoption and growth is a causal relationship rather than simply a correlation. The availability of contracting (the share of operations in a county using production contracts) should influence profitability of producing under contract relative to producing independently. There is no plausible reason to believe that the availability of contracting should influence the rate of farm growth directly. However, indirectly, contract availability should raise the relative profitability of contracting, increase the likelihood of contract adoption and thereby increase the rate of farm growth, through the mechanisms described.

**Empirical Approach**

To examine the effect of contract use on farm size for continuing operations, let the relationship between initial contract use and subsequent farm size change be described by the linear model:

1) $$S_{it+1} = \alpha_1 + \gamma_1 S_{it} + \delta_1 C_{it} + X'_{it}\beta_1 + \varepsilon_{1it},$$

where $S_{it}$ is the log of farm size for operation *i* in time *t*, $C_{it}$ is a dummy indicating production contract use in the initial period and $X_{it}$ are exogenous covariates. Since farm size is expressed in logs, the variable of interest $\delta_1$ can be interpreted as the percentage increase in farm size resulting from the use of a production contract.

To estimate the effect of contract use on farm business survival, let $Ex_{it+1}$ be an indicator for whether the operator has exited production. For the full sample, a logistic model is used to estimate the following equation:

2) $$Ex_{it+1} = \alpha_2 + \gamma_2 S_{it} + \delta_2 C_{it} + X'_{it}\beta_2 + \varepsilon_{2it},$$

To examine the relationship between contract adoption on farm size we consider only the sample of continuing operations that did not use a production contract in the initial period. Let the change in farm size be described by:

3) $$S_{it+1} = \alpha_3 + \gamma_3 S_{it} + \delta_3 C_{it+1} + X'_{it}\beta_3 + \varepsilon_{3it},$$

where $C_{it+1}$ is an indicator of contract adoption (i.e., indicating whether a contract was used $t+1$, since no operations used a contract in $t$). Because unobserved factors could affect both farm size and contract adoption, least squares estimates of $\delta_3$ (and the other parameters in the model) are generally biased and inconsistent. The method of instrumental variables can be used to obtain consistent parameter estimates if we can identify an instrument correlated with $S_{it+1}$ but not correlated with the error term.

In this study, the local (county-level) availability of production contracts is used as the instrument. In counties where contracts are more widely available, farms face lower transactions costs associated with obtaining and maintaining a contractual relationship compared to those in counties where contracts are not available or rarely used. In counties with greater contract availability, distances between contractors and growers are less, so the costs associated with search, information, and transportation are lower for farmers and contractors, making contracting relatively more profitable. It follows that farms in counties with greater contract availability should be more likely to adopt a contract in the subsequent five years, *ceteris paribus*. At the same time, it is reasonable to assume that the county-level availability of contracts is exogenous to an individual farm's investment decisions and should therefore have no direct effect on farm size growth (though contract availability could indirectly affect scale by influencing the decision to contract). Hence, the instrumental variables approach assumes that the local availability of contracts is not correlated with unobservable factors in (3) that influence farm size change.

Two-stage least squares implemented in SAS 9.1 is used to solve the instrumental variables model. In the first stage, the contracting adoption indicator is regressed on the availability of contracts $Av_{ict}$ (the instrument), along with controls for initial farm size and other operator and operation characteristics:

4) $$C_{it+1} = \alpha_4 + \gamma_4 S_{it} + X'_{it}\beta_4 + \theta Av_{ict} + \varepsilon_{4it}.$$

As emphasized by Angrist and Krueger (2001), in two-stage least squares, consistency of the second-stage estimates does not depend on using the correct first-stage functional form (Kelejian, 1971). That is, using a linear regression for the first-stage estimates generates consistent second-stage estimates even with a dummy dependent variable (the use of contracts, in this case). In fact, the linear model is generally preferred, as researchers risk specification error if they plug in fitted values from a logit, probit, or other nonlinear equations directly in the second step of a two-stage least squares procedure (Angrist and Krueger, p. 80).

In the second stage, the effect of contract adoption on farm size change (3) is estimated using the predicted values of contract adoption indicator from (4):

5) $$S_{it+1} = \alpha_3 + \gamma_3 S_{it} + \delta_3 \hat{C}_{it+1} + X'_{it}\beta_3 + \varepsilon_{3it}.$$

Since the predicted values are not correlated with the errors in (5), the two-stage approach produces consistent estimates of the parameters.

## Data

Data for the analysis are drawn from the 2002 and 2007 United States Census of Agriculture maintained by the USDA National Agricultural Statistics Service.[1] In 2002, the Census began asking farm operators about quantities delivered under production contracts. The Census classifies hogs as produced under a "production contract" if: 1) operators raised hogs that they did not own, and 2) the livestock owner (contractor) provided inputs such as feed, and 3) the operation received a fee or percentage of the production for raising the livestock. Using data from consecutive Censuses allows us to compare changes in the characteristics of operations organized as independent or production contract growers.

The Census categorizes finish hog producers as either "farrow-to-finish" or "finish-only", with finish-only operations responsible for about two-thirds of the total market hog output in 2007.[2] Farrow-to-finish operations are those on which pigs are farrowed (birthed) and raised to a slaughter weight of 240-270 pounds. Finish-only (sometimes called "feeder pig-to-finish") operations are those on which feeder pigs of 50-60 pounds are obtained (either purchased or placed via contract) from outside the operation and fed until they reach slaughter weight. Because these two types of operations involve different phases of the animal's life cycle, the operations differ in structure – with the farrow-to-finish operation requiring more capital and inputs per hog removed. These operations also differ in terms of organizational arrangement – about 25 percent of all finish-only operations used a production contract in 2007, compared to only 1 percent of farrow-to-finish operations. Because organizational arrangement is closely correlated with farm type and farm structure it would be difficult to attribute differences in growth and survival rates across farms to organizational arrangement versus other differences in

[1] For more information see: http://www.agcensus.usda.gov/ .
[2] According to the Census data, in 2007, independent and contract finish hog operations removed about 93 million head, of which 33% were removed from farrow-to-finish operations and 67% were removed from finish-only operations.

farm structure if both farrow-to-finish and finish-only farms were included in the analysis. Consequently, this study examines only finish-only operations.[3]

Of the 48,514 and 45,122 independent or production contract growers with positive hog production and inventory in the 2002 and 2007 Censuses, 18,847 and 18,662 were self-described as finish-only producers in 2002 and 2007, respectively. Of these, 10,994 and 9,806 were commercial operations (define as selling or removing at least 100 head) in 2002 and 2007, respectively.[4]

Figure 1 illustrates the distribution of all commercial finish-hog operations by organizational arrangement in 2002 and 2007. The figure illustrates that contract operations are much more likely to be larger in scale than independent operations. Hence, an increase in the prevalence of contracting (as occurred between 2002 and 2007) would tend to result in an increase in the average scale of production, as discussed in the introduction. The figure also reveals an increase in the scale of production for both independent and contract operations over the five-year period.

To examine the effect of initial (2002) organizational arrangement on farm growth we limit the sample to the 4,525 continuing finish-only operations. An operation was classified as continuing if it: 1) had a matching operator identification number (POID) in 2002 and 2007, 2) had a positive quantity of hogs sold or removed in 2007, 3) was self-classified as "finish-only" in 2007, and 4) the operator's age in 2007 was 4 to 6 years greater than the operator's age in 2002. We match operator's age across Censuses in order to keep only those operations with the same operator. This allows us to more precisely estimate on differences in farm size that resulted because of differences in organizational arrangement, rather than changes in operator characteristics.

For the analysis of the effect of initial organizational arrangement on farm survival we classify an operation as exiting or not exiting in 2007. An operation was defined as having exited if it: 1) had no matching operator identification number (POID) in 2002 and 2007, or 2) had no hogs sold or removed in 2007, or 3) was not self-classified as "finish-only" in 2007.[5]

[3] Hog farms in the other Census farm-type categories (farrow-to-wean, farrow-to-feeder, and nursery) are also not considered in this analysis because they differ substantially in structure from finish-only operations.
[4] These are the actual number of Census respondents, not estimates calculated using an expansion factor.
[5] Note that the operation is classified as not exiting even if the operator changed, as indicated by an age differential across Censuses periods outside the 4 to 6 year range. Hence, there is a small difference between the number of farms "not continuing" and the number "exiting".

To consider the effect of contract adoption on farm growth the sample is limited to "potential adopters" – i.e., the 1855 continuing operations (defined above) that were not using a production contract in 2002. The instrument, contract availability, is measured as the share of finish hog operations in a county that used a production contract.[6] The distribution of contract availability (share of producers with a contract) among potential contract adopters is shown in figure 2. None of the potential adopters are located in counties with 100% of farms contracting in 2002, because this sample consists only of farms that did not contract in 2002.

**Results**

Table 1 compares the farm-size growth of independent and contract continuing operations using four measures of growth. The table presents averages for the full sample and for four farm-size categories based on the head of hogs removed in 2002. In general, larger operations experienced larger gains in the number of head removed between 2002 and 2007. However, this growth represents a smaller percentage increase in scale for larger operations than for smaller operations. In aggregate (bottom 5 rows), there was no clear relationship between organizational arrangement and growth. However, for hog operations removing between 1000 and 5000 head (the two middle categories) contract operations grew significantly more than independent operations. For these mid-sized operations, those with production contracts grew about nine percentage points more than independent operations (in terms of average percent change) over the five years between Censuses. For small operations (100-999 head removed) the pattern was similar though weakly statistically significant. For very large operations (>5000 head removed) there was no statistically significant difference between contract and independent operations.

Next a regression analysis is used to examine whether the relationship between initial organizational arrangement and farm growth is maintained after controlling for observable operator and operation characteristics (table 2). The operator's age and age-squared and experience are included as controls for lifecycle factors correlated with investment and retirement decisions. State fixed effects are also included, but parameter estimates are not

[6] An operation was considered to have used a production contract if it delivered any hogs or pigs under a production contract in 2002.

reported. The State fixed effects control for differences in local economic conditions that could influence farm business investment decisions, such as differences in input and output prices, availability of processing facilities, transportation infrastructure, weather, and local agricultural policies and regulations etc.

Regression results indicate that for continuing operations having fewer than 5000 head, use of a production contract in 2002 is associated with greater growth in farm size. Specifically, the use of a production contract was associated with an additional 14.9, 11.4 and 9.5 percentage point increase in farm size for small, medium, and large farms, respectively, compared to observationally similar farms that did not use a production contract. There is no statistically significant relationship between contract use and farm growth for farms having at least 5000 head in 2002.

Table 3 shows the exit rates for the independent and contract operations by farm size category. The exit rates are high relative to those reported in other studies mainly because exits also include operators who switched from finish hog production to another type of farming, as discussed in the data section. There was a strong negative correlation between the exit rate and scale, for farms with fewer than 5000 head. For each size category, the exit rate for contract operations is lower than for independent operations. However, this difference is only statistically significant for the smallest and largest farm size categories. For the largest operations the difference in exit rates was large: 46% of independents contract operations exited between 2002 and 2007, compared to only 34% of contract operations.

Next, we use a logistic model to examine whether initial contract use is correlated with the likelihood of exiting finish hog production, controlling for observable operator and operation characteristics (table 5). The exit regression includes the same controls as the growth regression, including State fixed effects, which are not reported. Results indicate no statistically significant relationship between production contract use and the likelihood of exiting for operations with fewer than 5000 head. However, for operations with at least 5000 head, the use of a production contract in 2002 is associated with a 29 percentage point decrease in the likelihood of exiting between 2002 and 2007.

To summarize, we find that the correlation between production contract use and measures of farm structural change vary substantially by farm size. Contracting was found to be correlated with more growth in the scale of production for farms with fewer than 5000 head, and with an

increased likelihood of farm business survival for farms with 5000 head or more. In other words, for small and medium –scale operations, contracting is positively associated with farm growth, but not with farm survival. It is possible that production contracts facilitate access to productive credit that allows for greater farm expansion over time, help operators to "leverage" their financial resources by providing many of inputs to production, or facilitate access to more productive and profitable technologies. Apparently, beyond a point, these factors do not appear to be beneficial in terms of farm size growth. That contracting lowers farm income risk does not appear to be associated with a reduced risk of farm business failure for smaller operations, but it does for larger ones. That the failure rates of small contract and independent producers were not significantly different, once controls were included, suggests that smaller-scale contract operations face substantial risk even with a contract. It is possible that these contract operations are more highly leveraged, so that relatively smaller downturns in income are a more likely to result in farm failure. It is not clear why only the largest-scale operations should benefit from contract use in terms of reduced risk of business failure.

*Contract Adoption and Instrumental Variables*

Next we consider the effect of contract adoption on farm size growth for all continuing operations without production contracts in 2002. Table 5 compares the average growth for contract adopters (operations with production contracts in 2007) to non-adopters (independent producers in 2007). In aggregate, 18.6% of operations adopted a contract, with the adoption rate increasing with farm size. There was a strong statistically significant correlation between contract adoption and farm size change: on average, adopters grew by 918 head compared to 323 for independent operations. In terms of average percent change, adopters grew by 14% and non-adopters shrank in size by 1%.

The aggregate difference between contract adopters and non-adopters was caused mainly by differences among smaller-scale operations. For operations with fewer than 1000 head, adopters increased sales by 663 more head than non-adopters, which is equivalent to a 45 percentage point difference in average percent change. For medium-scale operations (1000-2499) the absolute increase in scale was even larger (1319 additional head removed), though as a proportion of output this additional growth was smaller (28 percentage points).

The effect of contract adoption for smaller-scale operations remains statistically significant even after we control for initial farm size, age, experience, and state fixed effects using a regression analysis (table 6). With the controls, contract adoption is associated with a 57 percent increase in farm size for farms in the smallest category and a 34 percent increase for farms with 1000-2499 head.

As discussed in the empirical approach section, a potential problem with the least squares regression is that unobservable factors influencing contract adoption are also associated with farm size growth, causing the estimated parameters to be biased. To address this potential endogeneity problem, we use the availability of contracting as an instrumental variable for contract adoption. Table 7 presents the results of the second stage of the instrumental variables estimation (equation (5)). The IV estimates for the contract adoption parameter are statistically significant only for the smallest size category. Results indicate that for farms with fewer than 1000 head, adoption of a production contract results in a 280 percentage point increase in farm size over five years beyond would have occurred had the operator not started to contract.

**Conclusion**

Recent decades have seen the simultaneous increase in the scale of production and in the use of production contracts in the hog sector. This paper explores empirically whether production contracts have facilitated the growth and survival of finished hog operations. The study takes advantage of recently collected information from the Census of Agriculture that permits us to compare the changes in farm size of individual independent and contract producers over time.

Results of the study indicate that contract adoption was associated with a very large increase in farm size for operations that initially have fewer than 1000 head of hogs. It is possible that adopting a production allows producers to obtain more credit for facility expansion than they would have been able to obtain without a contract. Banks may be willing to lend more to operators with production contracts because the contracts substantially reduce farm income risk. Long-term contracts might also help overcome the "hold-up" problem, and thereby encourage greater investment in hog-specific productive assets, by lowering market risks.

Results also indicate that for all but the largest operations (i.e., those with fewer than 5000 head) the use of a production contract was associated with greater subsequent farm size growth. It is possible that contracts facilitate the transfer and adoption of new production technologies that allow contract operations to produce more efficiently and operate a larger scale than independent operations. On the other hand, for operations with fewer than 5000 head, results indicate that the use of a production contract was not associated with significantly lower exit rates. This suggests that contract producers face similar vulnerabilities to farm business failure as independent operations of the same size. It is possible that even though operators with production contracts face less price risk, they are more highly leveraged (at a given farm size), which makes them more vulnerable to fluctuations in market conditions.

For very large-scale operations (those with more than 5000 head) the study found that production contracts influence farm structure in a substantially different way. Results indicate that contract adoption was not associated with an increase in the scale of production for the largest operations. Additionally, after adoption, the use of production contract was not associated with greater growth. It is likely that beyond a certain size, economies of scale in hog production are limited (Key, *et al*., 2008). Hence, large scale operations would not need to take advantage of scale-enhancing benefits provided by contracts, presuming these benefits existed. However, results indicate that production contracts are associated with substantially lower exit rates for large-scale operations. This suggests a compelling motivation for very large independent operations to adopt a production contract, as 28% of the large-scale potential adopters did between 2002 and 2007.

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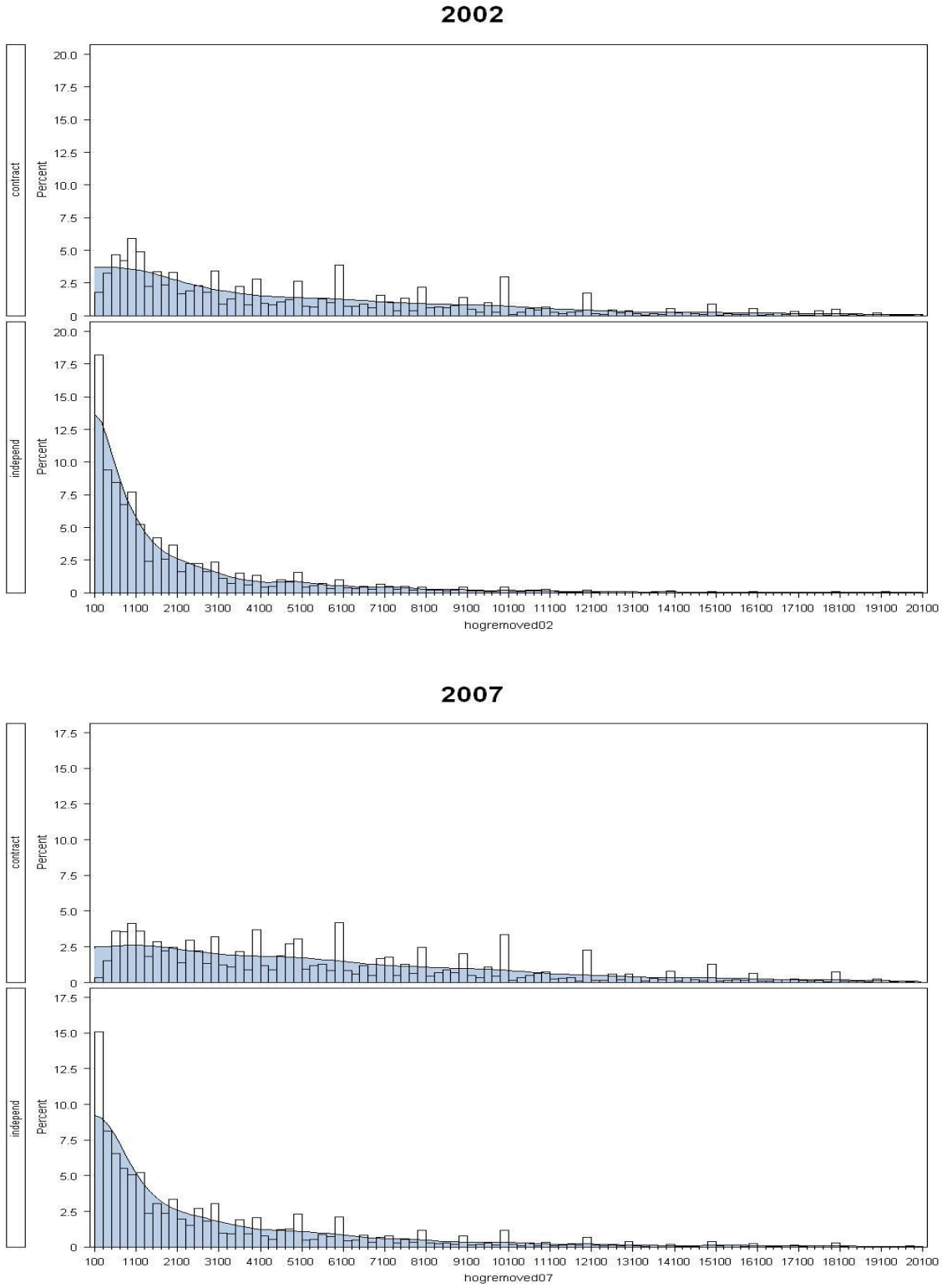
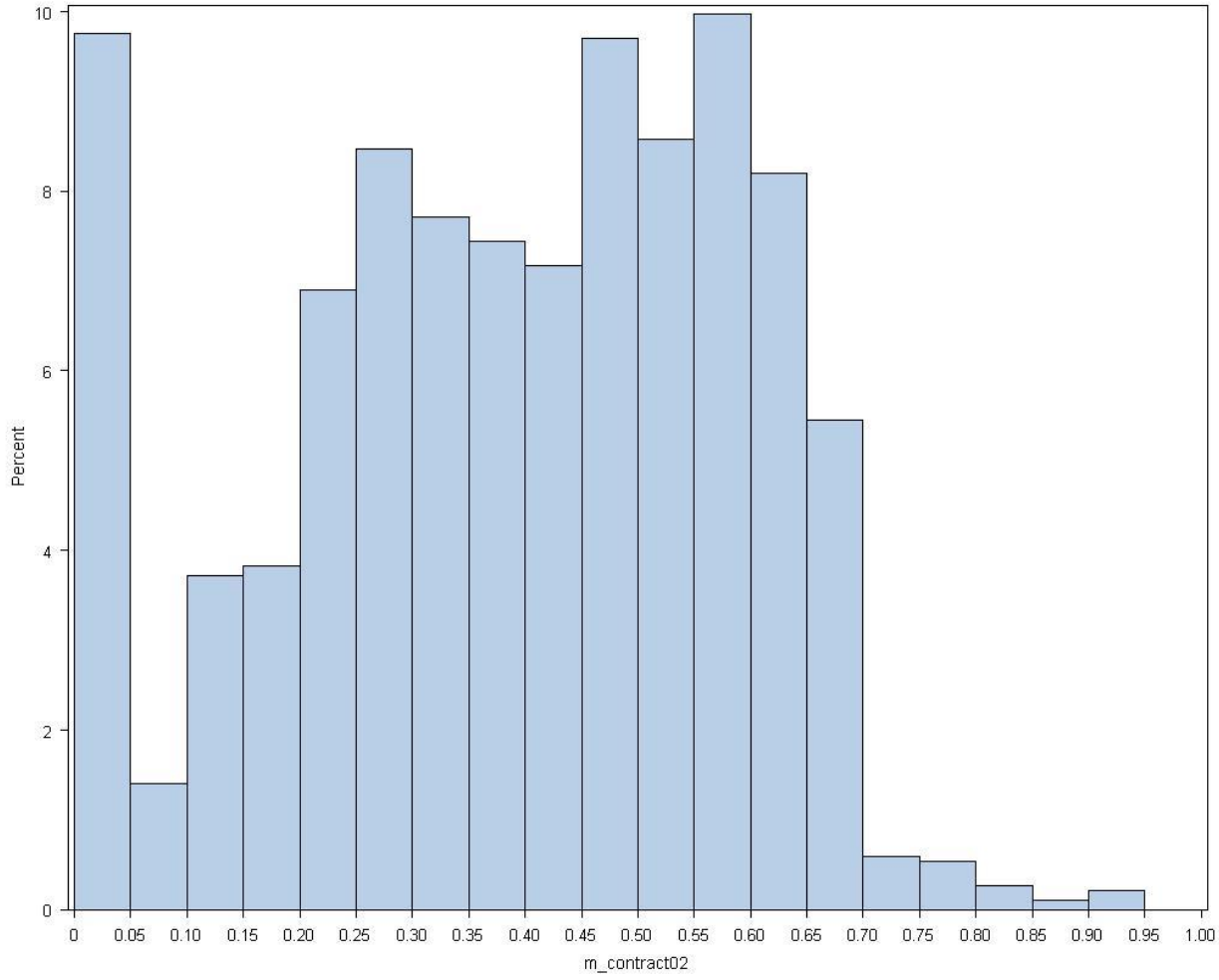
Figure 1. Size distribution of finish-only hog operations by organizational arrangement




Source: Census of Agriculture, 2002, 2007.

Figure 2. Distribution of Share of Hog Farms using a Production Contract in the County, Continuing Finish-only Operations




Source: Census of Agriculture, 2002.

Table 1. Change in Number of Head Removed for Continuing Finish-Only Hog Operations by Farm Size and Organizational Arrangement, 2002-07

| Measures of Farm Size Change, 2002-07 | 2007 Organizational Arrangement: Independent | 2007 Organizational Arrangement: Contract | Difference (Cont. – Ind.) | t-stat |
|---|---|---|---|---|
| 100-999 head removed 2002 | | | | |
| Change | 239 | 363 | 124 | 1.48 |
| Log change | 0.105 | 0.216 | 0.111 | 1.94* |
| Percent change | 57.0 | 82.9 | 25.9 | 1.42 |
| Av. percent change | 7.7 | 16.6 | 9 | 1.88* |
| Observations | 522 | 230 | | |
| 1000-2499 head removed 2002 | | | | |
| Change | 435 | 748 | 313 | 2.20** |
| Log change | 0.005 | 0.113 | 0.108 | 2.64*** |
| Percent change | 25.1 | 49.2 | 24.1 | 2.61*** |
| Av. percent change | 0.3 | 9.1 | 8.8 | 2.48** |
| Observations | 532 | 647 | | |
| 2500-4999 head removed 2002 | | | | |
| Change | 357 | 809 | 452 | 2.20** |
| Log change | -0.037 | 0.065 | 0.101 | 3.06*** |
| Percent change | 11.2 | 24.6 | 13.4 | 2.07** |
| Av. percent change | -3.0 | 5.6 | 8.6 | 2.96*** |
| Observations | 407 | 588 | | |
| 5000+ head removed 2002 | | | | |
| Change | 754 | 320 | -434 | -1.11 |
| Log change | -0.054 | -0.025 | 0.029 | 1.05 |
| Percent change | 8.9 | 7.0 | -1.9 | -0.56 |
| Av. percent change | -3.3 | -1.8 | 1.5 | 0.68 |
| Observations | 394 | 1365 | | |
| All | | | | |
| Change | 417 | 524 | 107 | 0.80 |
| Log change | 0.015 | 0.048 | 0.033 | 1.86* |
| Percent change | 28.7 | 27.3 | -1.4 | -0.33 |
| Av. percent change | 1.1 | 4.0 | 2.9 | 1.90* |
| Observations | 1855 | 2670 | | |

Notes: Asterisks denote rejection of the null hypothesis that the difference in means is zero at the (*) 10%; (**) 5%; and (***) 1% statistical significance levels. Change = $H_{2007} - H_{2002}$; Log change = $\log(H_{2007}) - \log(H_{2002})$; Percent change = $100*(H_{2007} - H_{2002})/ H_{2002}$; Av. percent change = $200*(H_{2007} - H_{2002})/ (H_{2002} + H_{2007})$.
Source: Census of Agriculture, 2002, 2007.

Table 2. Least Squares Estimates of 2007 Farm Size for Continuing Operations

| Variables | Parameter | Std. Err. | t-stat |
|---|---|---|---|
| 100-999 head removed 2002 | | | |
| Intercept | 2.910 | 0.450 | 6.46*** |
| Log head removed 2002 | 0.739 | 0.045 | 16.37*** |
| Contract 2002 | 0.149 | 0.057 | 2.58*** |
| Operator's age | -0.039 | 0.015 | -2.49** |
| Operator's age-squared | 0.0003 | 0.0002 | 1.87* |
| Experience | -0.0008 | 0.0036 | -0.21 |
| Adj. R-squared | 0.32 | | |
| Observations | 752 | | |
| 1000-2499 head removed 2002 | | | |
| Intercept | -1.124 | 0.645 | -1.74* |
| Log head removed 2002 | 1.072 | 0.074 | 14.42*** |
| Contract 2002 | 0.113 | 0.041 | 2.75*** |
| Operator's age | 0.026 | 0.012 | 2.09** |
| Operator's age-squared | -0.0003 | 0.0001 | -2.35** |
| Experience | 0.0010 | 0.0029 | 0.34 |
| Adj. R-squared | 0.18 | | |
| Observations | 1019 | | |
| 2500-4999 head removed 2002 | | | |
| Intercept | 1.072 | 0.715 | 1.5 |
| Log head removed 2002 | 0.928 | 0.083 | 11.18*** |
| Contract 2002 | 0.095 | 0.033 | 2.81*** |
| Operator's age | -0.018 | 0.011 | -1.56 |
| Operator's age-squared | 0.0002 | 0.0001 | 1.35 |
| Experience | -0.0014 | 0.0023 | -0.6 |
| Adj. R-squared | 0.13 | | |
| Observations | 995 | | |
| 5000+ head removed 2002 | | | |
| Intercept | 0.932 | 0.283 | 3.28*** |
| Log head removed 2002 | 0.896 | 0.023 | 37.66*** |
| Contract 2002 | 0.042 | 0.028 | 1.5 |
| Operator's age | 0.0014 | 0.0078 | 0.18 |
| Operator's age-squared | 0.0000 | 0.0001 | -0.43 |
| Experience | -0.0019 | 0.0014 | -1.4 |
| Adj. R-squared | 0.46 | | |
| Observations | 1759 | | |

Notes: Dependent variable: log head removed 2007. Asterisks denote rejection of the null hypothesis that the difference in means is zero at the (*) 10%; (**) 5%; and (***) 1% statistical significance levels.

Table 3. Exit Rate for Finish-Only Hog Operations by Farm Size and Organizational Arrangement, 2002-07

| | 2002 Organizational Arrangement | | | |
|---|---|---|---|---|
| | Independent | Contract | Difference (Cont. – Ind.) | t-stat |
| 100-999 head removed 2002 | | | | |
| Exit rate | 0.782 | 0.718 | -0.063 | -3.81*** |
| Observations | 2541 | 856 | | |
| 1000-2499 head removed 2002 | | | | |
| Exit rate | 0.596 | 0.571 | -0.025 | -1.29 |
| Observations | 1431 | 1199 | | |
| 2500-4999 head removed 2002 | | | | |
| Exit rate | 0.435 | 0.396 | -0.039 | -1.68* |
| Observations | 779 | 1036 | | |
| 5000+ head removed 2002 | | | | |
| Exit rate | 0.461 | 0.345 | -0.116 | -5.93*** |
| Observations | 810 | 2342 | | |
| All | | | | |
| Exit rate | 0.647 | 0.477 | -0.170 | -18.20*** |
| Observations | 5561 | 5433 | | |

Notes: Asterisks denote rejection of the null hypothesis that the difference in means is zero at the (*) 10%; (**) 5%; and (***) 1% statistical significance levels. Change = $H_{2007} - H_{2002}$; Log change = $\log(H_{2007}) - \log(H_{2002})$; Percent change = $100*(H_{2007} - H_{2002})/ H_{2002}$; Av. percent change = $200*(H_{2007} - H_{2002})/ (H_{2002} + H_{2007})$.
Source: Census of Agriculture, 2002, 2007.

Table 4. Logistic Model Estimates of 2007 Farm Business Exit

| Variable | Parameter | Std. Err. | Chi-sq. |
|---|---|---|---|
| 100-999 head removed 2002 | | | |
| Intercept | -5.504 | 0.620 | -78.92*** |
| Log head removed 2002 | 0.714 | 0.062 | 132.23*** |
| Contract 2002 | -0.004 | 0.042 | -0.01 |
| Operator's age | 0.015 | 0.021 | 0.55 |
| Operator's age-squared | -0.0004 | 0.0002 | -3.30* |
| Experience | 0.007 | 0.005 | 2.37 |
| Pseudo R-squared | 0.09 | | |
| Observations | 3397 | | |
| 1000-2499 head removed 2002 | | | |
| Intercept | -9.709 | 1.101 | -77.72*** |
| Log head removed 2002 | 1.042 | 0.129 | 65.09*** |
| Contract 2002 | -0.052 | 0.037 | -2.06 |
| Operator's age | 0.084 | 0.022 | 14.67*** |
| Operator's age-squared | -0.0010 | 0.0002 | -20.79*** |
| Experience | 0.004 | 0.005 | 0.55 |
| Pseudo R-squared | 0.04 | | |
| Observations | 2630 | | |
| 2500-4999 head removed 2002 | | | |
| Intercept | -6.447 | 1.937 | -11.08*** |
| Log head removed 2002 | 0.768 | 0.224 | 11.75*** |
| Contract 2002 | -0.075 | 0.046 | -2.67 |
| Operator's age | 0.038 | 0.028 | 1.76 |
| Operator's age-squared | -0.0006 | 0.0003 | -5.03** |
| Experience | 0.011 | 0.006 | 3.33* |
| Pseudo R-squared | 0.03 | | |
| Observations | 1815 | | |
| 5000+ head removed 2002 | | | |
| Intercept | 2.957 | 0.838 | 12.44*** |
| Log head removed 2002 | -0.345 | 0.069 | -25.04*** |
| Contract 2002 | -0.289 | 0.042 | -46.60*** |
| Operator's age | 0.032 | 0.023 | 1.96 |
| Operator's age-squared | -0.0005 | 0.0002 | -5.32** |
| Experience | 0.015 | 0.004 | 13.71*** |
| Pseudo R-squared | 0.05 | | |
| Observations | 3152 | | |

Note: Dependent Variable is Exit (1/0) in 2007. Asterisks denote rejection of the null hypothesis that the difference in means is zero at the (*) 10%; (**) 5%; and (***) 1% statistical significance levels.

Table 5. Change in Number of Head Removed for Finish-Only Hog Operations by Farm Size and Contract Adoption, 2002-07

| Measures of Farm Size Change, 2002-07 | 2007 Organizational Arrangement: Independent (Non-adopter) | 2007 Organizational Arrangement: Contract (Adopter) | Difference (Cont. – Ind.) | t-stat |
|---|---|---|---|---|
| 100-999 head removed 2002 | | | | |
| Change | 170 | 833 | 663 | 4.63*** |
| Log change | 0.048 | 0.583 | 0.535 | 5.33*** |
| Percent change | 43.5 | 172.1 | 128.6 | 4.19*** |
| Av. percent change | 3.0 | 47.9 | 44.9 | 5.33*** |
| Observations | 468 | 54 | | |
| 1000-2499 head removed 2002 | | | | |
| Change | 212 | 1532 | 1319 | 6.07*** |
| Log change | -0.052 | 0.283 | 0.335 | 4.67*** |
| Percent change | 11.6 | 91.9 | 80.3 | 6.23*** |
| Av. percent change | -4.5 | 23.7 | 28.2 | 4.50*** |
| Observations | 446 | 86 | | |
| 2500-4999 head removed 2002 | | | | |
| Change | 254 | 861 | 607 | 1.92* |
| Log change | -0.040 | -0.020 | 0.020 | 0.28 |
| Percent change | 8.1 | 26.4 | 18.4 | 1.86* |
| Av. percent change | -3.0 | -3.0 | -0.1 | -0.01 |
| Observations | 341 | 66 | | |
| 5000+ head removed 2002 | | | | |
| Change | 890 | 261 | -629 | -0.92 |
| Log change | -0.038 | -0.109 | -0.070 | -0.98 |
| Percent change | 9.4 | 7.1 | -2.4 | -0.32 |
| Av. percent change | -1.9 | -8.5 | -6.5 | -1.13 |
| Observations | 308 | 86 | | |
| All | | | | |
| Change | 323 | 918 | 595 | 3.23*** |
| Log change | -0.015 | 0.174 | 0.189 | 4.70*** |
| Percent change | 20.7 | 71.4 | 50.8 | 5.60*** |
| Av. percent change | -1.3 | 14.3 | 15.6 | 4.56*** |
| Observations | 1563 | 292 | | |

Notes: Sample consists of operations that did not use a production contract in 2002. Asterisks denote rejection of the null hypothesis that the difference in means is zero at the (*) 10%; (**) 5%; and (***) 1% statistical significance levels. Change = $H_{2007} - H_{2002}$; Log change = $\log(H_{2007}) - \log(H_{2002})$; Percent change = $100*(H_{2007} - H_{2002})/ H_{2002}$; Av. percent change = $200*(H_{2007} - H_{2002})/ (H_{2002} + H_{2007})$.
Source: Census of Agriculture, 2002, 2007.

Table 6. Least Squares Estimates of 2007 Farm Size for Potential Contract Adopters

| Variable | Parameter | Std. Err. | t-stat |
|---|---|---|---|
| 100-999 head removed 2002 | | | |
| Intercept | 2.072 | 0.541 | 3.83*** |
| Log head removed 2002 | 0.781 | 0.048 | 16.12*** |
| Contract adoption (2002-07) | 0.570 | 0.099 | 5.75*** |
| Operator's age | -0.020 | 0.019 | -1.04 |
| Operator's age-squared | 0.0002 | 0.0002 | 0.99 |
| Experience | -0.0075 | 0.004 | -1.79* |
| Adj. R-squared | 0.39 | | |
| Observations | 522 | | |
| 1000-2499 head removed 2002 | | | |
| Intercept | -2.659 | 0.836 | -3.18*** |
| Log head removed 2002 | 1.174 | 0.096 | 12.26*** |
| Contract adoption (2002-07) | 0.338 | 0.071 | 4.74*** |
| Operator's age | 0.054 | 0.017 | 3.08*** |
| Operator's age-squared | -0.0005 | 0.0002 | -3.01*** |
| Experience | -0.0005 | 0.004 | -0.12 |
| Adj. R-squared | 0.26 | | |
| Observations | 532 | | |
| 2500-4999 head removed 2002 | | | |
| Intercept | -0.333 | 1.164 | -0.29 |
| Log head removed 2002 | 1.041 | 0.135 | 7.71*** |
| Contract adoption (2002-07) | 0.010 | 0.072 | 0.15 |
| Operator's age | 0.005 | 0.021 | 0.24 |
| Operator's age-squared | 0.0000 | 0.0002 | -0.2 |
| Experience | -0.0077 | 0.005 | -1.66* |
| Adj. R-squared | 0.14 | | |
| Observations | 407 | | |
| 5000+ head removed 2002 | | | |
| Intercept | -0.037 | 0.789 | -0.05 |
| Log head removed 2002 | 0.950 | 0.069 | 13.77*** |
| Contract adoption (2002-07) | -0.092 | 0.072 | -1.28 |
| Operator's age | 0.027 | 0.021 | 1.29 |
| Operator's age-squared | -0.0003 | 0.0002 | -1.61 |
| Experience | -0.0024 | 0.004 | -0.54 |
| Adj. R-squared | 0.34 | | |
| Observations | 394 | | |

Notes: Dependent variable is log head removed 2007. Contract adoption is an indicator of production contract use in 2007. Asterisks denote rejection of the null hypothesis that the difference in means is zero at the (*) 10%; (**) 5%; and (***) 1% statistical significance levels.

Table 7. Production Contract Adoption and Farm Size Change, Instrumental Variables Two-Stage Least Squares Estimates, Dependent Variable: Log Head Removed 2007

| Variable | Parameter | Std. Err. | t-stat |
|---|---|---|---|
| 100-999 head removed 2002 | | | |
| Intercept | 2.679 | 0.798 | 3.36*** |
| Log head removed 2002 | 0.664 | 0.082 | 8.10*** |
| Contract adoption (2002-07) | 2.804 | 0.884 | 3.17*** |
| Operator's age | -0.030 | 0.026 | -1.15 |
| Operator's age-squared | 0.00038 | 0.00026 | 1.45 |
| Experience | -0.011 | 0.0061 | -1.90* |
| Adj. R-squared | 0.23 | | |
| Observations | 522 | | |
| 1000-2499 head removed 2002 | | | |
| Intercept | -2.658 | 0.835 | -3.18*** |
| Log head removed 2002 | 1.176 | 0.098 | 12.00*** |
| Contract adoption (2002-07) | 0.296 | 0.396 | 0.75 |
| Operator's age | 0.053 | 0.017 | 3.00*** |
| Operator's age-squared | -0.00051 | -.00017 | -2.97*** |
| Experience | -0.00046 | 0.0040 | -0.11 |
| Adj. R-squared | 0.23 | | |
| Observations | 532 | | |
| 2500-4999 head removed 2002 | | | |
| Intercept | -0.864 | 1.698 | -0.51 |
| Log head removed 2002 | 1.115 | 0.219 | 5.08*** |
| Contract adoption (2002-07) | 0.317 | 0.703 | 0.45 |
| Operator's age | -0.0013 | 0.026 | -0.05 |
| Operator's age-squared | 0.00003 | 0.00028 | 0.13 |
| Experience | -0.0078 | 0.0047 | -1.65* |
| Adj. R-squared | 0.13 | | |
| Observations | 407 | | |
| 5000+ head removed 2002 | | | |
| Intercept | 0.066 | 0.866 | 0.08 |
| Log head removed 2002 | 0.946 | 0.075 | 12.57*** |
| Contract adoption (2002-07) | 0.515 | 0.661 | 0.78 |
| Operator's age | 0.015 | 0.025 | 0.63 |
| Operator's age-squared | -0.00023 | 0.00024 | -0.93 |
| Experience | 0.0012 | 0.0061 | 0.20 |
| Adj. R-squared | 0.30 | | |
| Observations | 394 | | |