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Production Contracts and Farm Business Growth and Survival

Nigel Key

Using farm-level panel data from the U.S. Census of Agriculture, this research examines whether hog producers with production contracts increased output more, or were more likely to survive in business over 5 years, compared with independent producers. Additionally, this research examines whether independent producers who adopted a production contract grew more than similar independent operations who did not contract. The local availability of contracts serves as an instrumental variable to address the potential endogeneity of the contracting decision. Results indicate that the use and adoption of production contracts affect farm size growth and survival differently depending on the initial size of an operation.

Key Words: production contracts, farm structure, business survival, instrumental variables, hog production

JEL Classifications: D23, J43, L25, Q12

In the U.S. hog sector, production contracts are becoming increasingly common: the share of hogs grown under a production contract rose from approximately 5% in 1992 to 40% in 1998 and to 67% in 2004 (Key and McBride, 2007). Under a typical contract, an operator provides labor, equipment, and housing, whereas the contractor provides feed, feeder pigs, and veterinary and transportation services. The operator may receive a flat fee per hog or a fee based on weight gain or feed efficiency.¹ Production contracts

provide several benefits that might explain their growing prevalence, including lower income risk for growers, reduced transactions costs, and enhanced control over product quality and flow for packers (Hennessy and Lawrence, 1999; MacDonald et al., 2004). However, the shift to contract production has been controversial and has spurred legislative initiatives to protect contract farmers from unfair contract provisions, to provide growers with additional information about contract terms, and to regulate or ban packer ownership of livestock.

Growth in the use of production contracts has been accompanied by pronounced increases in the scale of production. Between 1992 and 2007, the number of U.S. farms selling hogs and pigs declined over 60%, from 188,200 to 74,800, whereas the number of head sold almost doubled (U.S. Department of Agriculture [USDA], 1994, 2009). At the same time, farms selling at least 5,000 head increased their share of the total number of hogs and pigs sold from 28–87 percent (USDA, 1994, 2009). The increase in the scale of production has enhanced production efficiency but has also raised concerns about water and air pollution,

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The views expressed are those of the author and do not necessarily reflect the views or policies of the U.S. Department of Agriculture.

¹This study is concerned with production contracts, which are distinct from marketing contracts. Marketing contracts (including forward contracts, procurement contracts, and marketing agreements) govern the terms of sale but not the provision of inputs. Growers may have a production contract with a packer or with an integrator. An integrator contractor will often have production contracts with several hog producers and will sell the finished hogs to a packer under a marketing contract. Most independent hog producers sell their hogs in spot markets, although some independent growers have marketing contracts with packers or integrators (Vukina et al., 2007).

food safety, rural development, and animal welfare (e.g., Gurian-Sherman, 2008; Natural Resource Defense Council, 2010; Pew Commission on Industrial Farm Animal Production, 2009).

It is plausible that the growth in contracting has facilitated the transition toward larger operations (Key, 2004). By shifting price risks from growers to contractors, production contracts may help growers to weather market downturns and remain in business longer (Johnson and Foster, 1994; Knoeber and Thurman, 1995; Martin, 1997). Because contracts lower price and consequently income risk, lenders may be more willing to approve loan requests or offer lower interest rates to operators with contracts. With enhanced access to credit, contract growers could invest more in productive capital and thereby achieve greater scale (Boehlje and Ray, 1999).

Production contracts may also facilitate farm size growth by reducing operators' financing requirements for variable inputs. Under a production contract to finish hogs, the feed and other inputs supplied by a contractor represent, on average, over 80% of variable costs (Key and McBride, 2007). Hence, growers who are constrained in their access to financing could achieve a larger scale by producing under contract.

Contracts might also encourage greater investment in specific assets by helping to overcome hold-up problems. Specific assets are those having physical characteristics tailored to a particular purchaser. Specialized hog production equipment such as manure storage facilities, manure handling equipment, barns, etc., has little value outside of hog production. When there is 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 (Vukina and Leegomonchai, 2006). Long-term contracts could 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.

Contracting may also facilitate technological changes that reduce costs or 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 such productivity gains are accompanied by increases in the optimal scale of production and thus promote farm size growth.

Although there are several plausible theoretical reasons to expect a link between the use of production contracts and farm structure, there have been few empirical examinations of this connection. I am only aware of one study (Dong, Hennessy, and Jensen, 2010) that examined whether the use of production contracts influenced the probability of exiting farming and am not aware of any studies examining the link between contracts and farm size. Understanding whether production contracts facilitate the growth and survival of farm businesses is important for understanding the structural implications of policies that regulate or restrict contracting.

One reason for the limited number of empirical analyses may be the difficulty in accounting for the endogeneity of the contract decision. Dong, Hennessy, and Jensen (2010) developed a model illustrating why one might observe an association between contract use and farm size and survival that results from differences in exogenous grower characteristics rather than from the use of production contracts. In particular, they show that growers who possess attributes that allow them to survive longer (perhaps by being better able to use new technologies or manage enterprise finances), or are more cost-efficient, or who find it less costly to contract would be more likely to contract and less likely to exit. Their model demonstrates the need to account for potential sample selection bias in empirical examinations of the effect of contracting on farm size or survival.

Dong, Hennessy, and Jensen (2010) account for the potential endogeneity of the contract and farm exit decisions using a recursive bivariate

probit model. The authors analyzed 420 feeder pig-to-finish farms drawn from a cross-sectional survey. They classified an operation as exiting if the operator expected to continue producing hogs for 10 or fewer additional years. The authors found that use of a production contract reduces the probability of exiting.

In this study, farm-level panel data are used to examine the effect of production contracts on both farm survival and farm size. Data for the analysis are drawn from the 2002 and 2007 USDA Census of Agriculture, which provide information on production contract use and allow us to observe whether individual farm businesses survive and how they change in size over time. The comprehensive nature of the Census—which includes most U.S. hog producers—minimizes measurement errors associated with sample design and response rates and allows for state fixed effects to control for unobserved location-specific factors.

The large number of observations also provides sufficient degrees of freedom to test whether contracting has different effects on farm growth and survival for farms with different initial sizes. It is possible that operators of small-scale facilities adopt production contracts primarily to obtain access to larger loans so as to expand production and achieve a more efficient scale. In contrast, operators of large-scale facilities who are already operating at an optimal scale might instead adopt contracts to take advantage of their risk-mitigating features.

First used are ordinary least square (OLS) regressions to examine how initial contract status is associated with subsequent farm growth and survival; that is, to determine whether operations with production contracts in 2002 grew faster or were more likely to survive over the subsequent 5-year period than similar independent operations.² Also examined are whether an operator's adoption of a production contract is associated with farm size growth. Specifically, the growth rate of hog farms that

were producing independently in 2002 and who began to contract between 2002 and 2007 are compared with the growth rates of similar farms that continued to produce independently over this period.

The regressions determine whether an association between contracting and farm size and survival is maintained after controlling for observables but do not establish whether a link is causal. Unobservable factors associated with the decision to contract could also be associated with farm size growth or survival, which could bias the OLS parameters. To address this potential endogeneity problem, the local availability of contracting is used as an instrumental variable for contract adoption and use. The availability of contracting (the share of operations in a county using production contracts) should influence the profitability of producing under contract relative to producing independently. There is no plausible reason to believe that the local availability of contracting should influence individual farm growth and survival directly. The instrumental variable method makes it credible to assert that association between contract adoption or use and hog business growth or survival is a causal relationship rather than simply a correlation.

Empirical Approach

There is a substantial theoretical and empirical literature relating firm size and growth and survival. Ericson and Pakes (1992), Jovanovic (1982), and Pakes and Ericson (1998) developed models in which firms (or entrepreneurs) are uncertain about their own efficiencies at startup but gradually learn about their abilities over time. The longer an entrepreneur operates in the market, the more information he or she gathers. Those entrepreneurs who revise their perceptions of their ability upward tend to expand, whereas those revising downward tend to contract or exit. Consequently, the longer a firm has existed, the bigger it will be and the less likely it will be to fail. Empirical studies have generally confirmed these theoretical predictions (e.g., Audretsch, 1991; Audretsch and Mahmood, 1995; Baldwin and Gorecki, 1991; Dunne, Roberts, and Samuelson, 1988).

²The term "independent" is used to refer to growers that did not use a production contract. Independent growers might have marketed their finished hogs using marketing contracts or spot markets. See Vukina et al. (2007) for a detailed description of the finished hog market.

In addition to firm size and experience, the age of the operator has been shown to be an important determinant of survival and growth for farm businesses (Key and Roberts, 2006; Kimhi and Bollman, 1999; Sumner and Leiby, 1987; Weiss, 1999; Zepeda, 1995). The operator's age may be correlated to knowledge about the firm's competitive abilities with older owners able to acquire more information. Alternatively, the operator's age may be related to financial liquidity; in the presence of liquidity constraints, it may take many years for business owners to accumulate sufficient net worth to obtain a desired scale of production.

Accounting for these determinants of farm business growth, let the relationship between initial contract use and subsequent farm size change be described by

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

for continuing (surviving) operations, where S_{it} is the log of farm size for operation i in time t , C_{it} is a dummy indicating production contract use, and X_{it} are exogenous covariates such as operator age. The coefficient of interest δ_1 indicates the percentage increase in farm size resulting from the use of a production contract.

For operations in business in period t , let the association between contract use and farm business survival be similarly described by

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

where B_{it+1} is an indicator variable that equals one if an operation continued in business in period $t + 1$ and is zero if it exited. The coefficient δ_2 indicates the percentage point increase in the likelihood of the business surviving associated with the use of a production contract.

To examine the effect of contract adoption on farm size, the sample is limited to continuing "potential adopters"—continuing operations that did not use a production contract in the initial period. The change in farm size is described by

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

where C_{it+1} is an indicator of contract adoption (i.e., indicating whether a contract was used in period $t + 1$, because no operations used a contract in t).

Instrumenting for Contract Use and Contract Adoption

As discussed previously, unobserved factors that influence both the outcome variables and contract use (or adoption) could cause the least squares parameters in equations (1)–(3) to be biased and inconsistent. The method of instrumental variables can be used to obtain consistent parameter estimates if it is possible to identify an instrument correlated with the treatment (contract use/adoption) but not correlated with the error term.

In this study, the local (county-level) availability of production contracts is used as an instrument for contract use in equations (1) and (2) and for contract adoption in equation (3). In counties where contracts are more widely available, farms face lower transactions costs associated with obtaining and maintaining a contractual relationship compared with 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 contracting transaction 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 use or adopt a contract, *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 (although 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 that influence farm size or business survival.

For the instrumental variables two-stage least squares (IV-2SLS) approach, the contracting use or adoption indicator is first regressed on the availability of contracts in the county A_{ct} (the instrument) along with controls for initial farm size and other operator and operation characteristics. For equations (1) and (2), the first stage is

$$(4) \quad C_{it} = \alpha_4 + \gamma_4 S_{it} + X'_{it} \beta_4 + \theta A_{ct} + \varepsilon_{4i}.$$

For equation (3), the first stage is identical except the dependent variable is C_{it+1} . The linear regression for the first-stage estimates generates consistent second-stage estimates and is generally preferred, because 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, 2001, p. 80).

In the second stage, the effect of contract use on farm size or survival is estimated using the predicted values from the first stage. For example, the effect of contract use on farm size (equation [1]) would be estimated:

$$(5) \quad S_{it+1} = \alpha_5 + \gamma_5 S_{it} + \delta_5 \hat{C}_{it} + X'_{it} \beta_5 + \varepsilon_{5i}.$$

The second-stage estimation of the effect of contract use on survival is specified using the linear probability model (equation [2]) primarily for simplicity. As Angrist and Pischke (2009, pp. 197–204) demonstrate, an IV-2SLS approach produces very similar estimates to bivariate probit models and to the semiparametric estimators proposed by Adabie (2003). The two-stage least squares approach has the advantage of not requiring questionable structural model assumptions nor complicated calculations of the marginal effects.³

Addressing Selection Bias from Sample Attrition

The IV-2SLS estimates of the effect of contract use on farm survival that use the full sample should be unbiased. However, the IV-2SLS estimates of the effect of contract use or contract adoption on farm size that use the sample of surviving farms could be biased as a result of sample attrition if unobservable factors are correlated with the likelihood of survival and farm growth. For example, suppose that contract use and an unobservable factor such as

“farming ability” are both positively correlated with the probability of survival and the rate of farm growth. If this were the case, then farmers with high ability will be overrepresented among the sample of survivors. Selection bias arises because within the sample of survivors, ability is negatively correlated with contracting: farmers must have high levels of ability if they do not have a contract, and farmers with low ability need the benefits from contracting to survive. Estimates of the effect of contracting on farm size would therefore be biased toward zero.

Potential sample selection bias from attrition is addressed using a two-step Heckman selection model (Heckman, 1979). In the first step, the selection equation (surviving in business) is estimated using a probit model:

$$(6) \quad B_{it+1} = \alpha_6 + \gamma_6 S_{it} + \delta_6 A_{it} + X'_{it} \beta_6 + \varepsilon_{6i},$$

where the local availability of contracting A_{it} is used instead of the contract indicator C_{it} . Unlike contract use, which is endogenously determined with survival, the local availability of contracts is exogenous to business survival (although it is correlated with contract use, as discussed previously). Because of this, the probit parameters estimates of equation (6) are consistent and can be used to compute the inverse Mills ratio used in the second step.

In the two-step Heckman, the errors in the selection equation (6) and the farm size equation (1) are assumed to have a bivariate normal distribution:

$$(7) \quad \begin{bmatrix} \varepsilon_{6i} \\ \varepsilon_{1i} \end{bmatrix} \sim N \left(\begin{bmatrix} 0 \\ 0 \end{bmatrix}, \begin{bmatrix} 1 & \rho \\ \rho & \sigma_1^2 \end{bmatrix} \right).$$

It follows that the expected farm size growth conditional on survival is

$$(8) \quad E[S_{it+1} | B_{it+1} = 1] = \alpha_1 + \gamma_1 S_{it} + \delta_1 C_{it} + X'_{it} \beta_1 + \rho \sigma \lambda_i$$

where λ_i is the inverse Mills ratio.⁴ In the second step, parameters from the probit

³ Angrist and Pischke (2009) also argue for using OLS because it always gives a minimum mean squared error linear approximation of the conditional expectation function and because it has the virtue of simplicity, automation, and comparability across studies.

⁴ The inverse Mills ratio is defined: $\lambda_i = \phi(Z'_{it} \theta_6) / \Phi(Z'_{it} \theta_6)$, where Z'_{it} are all the covariates in the selection equation (6), θ_6 are the associated parameters, $\phi(\bullet)$ is the standard normal probability density function, and $\Phi(\bullet)$ is the standard normal cumulative distribution function.

estimation of equation (6) are used to compute the estimated inverse Mills ratio $\hat{\lambda}_i$, which is included as an additional term in the estimation of equation (1). An analogous two-step approach is used for the sample of all potential contract adopters to address selection bias in the estimation of the effect of contract adoption on farm size (equation [3]). However, because potential adopters did not contract in the initial period, the selection equation (6) for potential adopters does not include the term $\delta_6 A_{it}$.

Data

Data for the analysis are drawn from the 2002 and 2007 U.S. Census of Agriculture maintained by the USDA National Agricultural Statistics Service. The Census collects data on farm and operator characteristics every 5 years from most farms in the country.⁵ 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 approximately two-thirds of the total market

hog output in 2007.⁶ 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 through 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 types of operations also differ in terms of organizational arrangement; approximately 25% of all finish-only operations used a production contract in 2007 compared with only 1% 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 vs. other differences in farm structure if both farrow-to-finish and finish-only farms were included in the analysis. Consequently, this study examines only finish-only operations.⁷

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.⁸

A 2002 commercial finish-only operation was classified as surviving (continuing) in the

⁵ Census administrators attempt to reach all agricultural operations that produce, or would normally produce and sell, \$1,000 or more of agricultural products per year. Data are primarily collected through the mail, with supplemental reporting on the Internet and non-response follow-ups by telephone and personal enumeration. The final response rates were 88.0% and 85.2% for the 2002 and 2007 Censuses, respectively. National Agricultural Statistics Service reports a probability weight for each observation to correct for under-coverage and nonresponse. These weights are used in this study to estimate sample statistics and regression coefficients. For more information, see www.agcensus.usda.gov/.

⁶ According to the Census data, in 2007, independent and contract finish hog operations removed approximately 93 million head, of which 33% were removed from farrow-to-finish operations and 67% were removed from finish-only operations.

⁷ 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.

⁸ These are the actual number of Census respondents, not estimates calculated using an expansion factor.

hog business if it 1) had a matching operator identification number in 2002 and 2007; 2) remained a commercial hog operation (sold or removed at least 100 hogs in 2007); 3) remained classified as “finish-only” 2007; and 4) the operator’s age in 2007 was 4–6 years greater than the operator’s age in 2002. The operator’s age is matched across Censuses to keep only those operations with the same operator. Holding operator characteristics the same (by removing operations that changed operator) allows more precise estimates of the effect of organizational arrangement on farm size. There were 4,525 commercial finish-only operations that survived in business between 2002 and 2007.

To consider the effect of contract adoption on farm growth, the sample is limited to potential adopters; i.e., the surviving operations (as defined previously) that were not using a production contract in 2002. There are 1,855 potential adopters.

Summary statistics for all commercial finish-only hog producers, continuing operations, and potential adopters are shown in Table 1. For all three groups, the average scale of production increased substantially between 2002 and 2007. For the full sample, the share using a contract increased from 48% to 53%, whereas the average age and experience of operators increased by approximately 2 years. Compared with the full sample, continuing operations were somewhat larger on average, and potential adopters were somewhat smaller.

The instrument, contract availability, is measured as the share of finish-only hog operations in a county that used a production contract in 2002. The distribution of contract availability (share of producers with a contract) among potential contract adopters is shown in Figure 1. None of the potential adopters are located in counties where 100% of farms contracted in 2002, because the potential adopters sample consists only of farms that did not contract in 2002.

Table 1. Summary Statistics for Commercial Finish-Only Hog Operations

	2002		2007	
	Mean	SD	Mean	SD
All				
Head of hogs removed	3,996	9,138	5,486	11,896
Production contract (1/0)	0.48	0.54	0.53	0.54
Operator’s age	48.6	12.6	50.8	12.6
Experience	22.0	13.2	24.4	13.5
Observations	10,994		9,806	
Continuing				
Head of hogs removed	4,933	6,734	5,501	7,725
Production contract (1/0)	0.58	0.53	0.58	0.52
Operator’s age	47.0	11.0	52.2	11.3
Experience	21.1	11.7	26.3	12.0
Observations	4,525		4,525	
Potential adopters				
Head of hogs removed	2,987	4,611	3,500	6,247
Production contract (1/0)	0	0	0.15	0.38
Operator’s age	47.7	11.1	52.8	11.1
Experience	23.1	11.6	28.2	11.5
Observations	1,855		1,855	

Notes: Commercial operations are defined as having removed at least 100 head of hogs from the operation in the survey year. Continuing operations are defined as having remained in business as finish-hog producers. Potential contract adopters are continuing operations that did not use a production contract in 2002.

Source: Census of Agriculture, 2002, 2007.

SD, standard deviation.

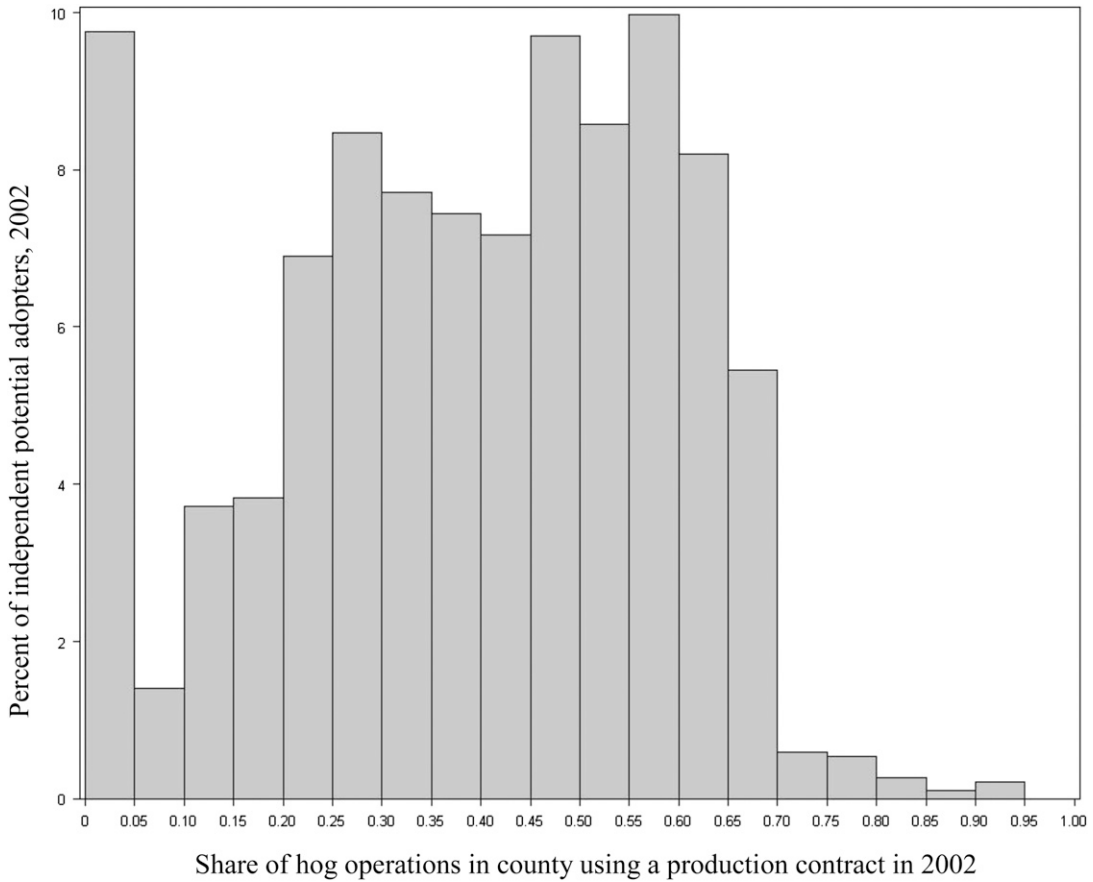


Figure 1. Variation in Contract Availability across Potential Adopters (Source: Census of Agriculture, 2002)

Results

Using the number of head removed as a measure of farm size, Table 2 shows the farm-size growth of independent and contract operations that were in business in both periods. The table presents average values of four measures of growth for the full sample and for four farm-size categories. 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 for larger operations than for smaller operations. In aggregate (bottom five rows), there was not a strong relationship between organizational arrangement and growth. However, for hog operations removing between 1,000 and 4,999 head (the two middle categories), contract operations grew significantly

more than independent operations. For these mid-sized operations, those with production contracts grew approximately nine percentage points more than independent operations (in terms of average percent change) over the 5 years between Censuses. For small operations (100–999 head removed), the pattern was similar although weakly statistically significant. For very large operations (greater than 5,000 head removed), there was no statistically significant difference between contract and independent operations.

An OLS regression analysis shows that the relationships between initial organizational arrangement and farm growth are maintained after controlling for observable operator and operation characteristics (columns 1, Table 3). In the regression, operator’s age and age squared and experience are included as controls for

Table 2. Change in Number of Head Removed for Continuing Operations by Initial Farm Size and Organizational Arrangement, 2002–2007

	Independent 2002	Contract 2002	Difference (contract – independent)	t-stat
Size 1 (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
Average percent change	7.7	16.6	9.0	1.88*
Observations	522	230		
Size 2 (1,000–2,499 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***
Average percent change	0.3	9.1	8.8	2.48**
Observations	532	647		
Size 3 (2,500–4,999 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**
Average percent change	-3.0	5.6	8.6	2.96***
Observations	407	588		
Size 4 (5,000+ 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
Average percent change	-3.3	-1.8	1.5	0.68
Observations	394	1,365		
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
Average percent change	1.1	4.0	2.9	1.90*
Observations	1,855	2,670		

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 = $100*(H_{2007} - H_{2002})/H_{2002}$; Average percent change = $200*(H_{2007} - H_{2002})/(H_{2002} + H_{2007})$.

Source: Census of Agriculture, 2002, 2007.

life-cycle factors correlated with investment and retirement decisions. State fixed effects are also included, but parameter estimates are not 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.

To allow the effects of contract use or adoption to vary with farm size in all the

regressions and second-stage equations, the contract indicators are interacted with j farm-size category indicators, D_{jit} . For example, using four size categories, equation (1) becomes

$$(1') \quad S_{it+1} = \alpha_1 + \gamma_1 S_{it} + \delta_1 D_{1it} C_{it} + \varphi_2 D_{2it} + \delta_2 D_{2it} C_{it} + \dots + \varphi_4 D_{4it} + \delta_4 D_{4it} C_{it} + X'_{it} \beta_1 + \varepsilon_{1i}.$$

The “missing” category in equation (1') contains operations in size category 1 that do not contract. Consequently, δ_1 measures the effect

Table 3. Contract Use and Farm Size Growth for Continuing Operations

Variables	(1) OLS Regression		(2) IV-2SLS Regression		(3) IV-2SLS Regression	
	Parameter	SE	Parameter	SE	Parameter	SE
Intercept	1.137***	0.198	1.247***	0.207	1.302***	0.270
Log head removed 2002	0.847***	0.021	0.821***	0.025	0.809***	0.047
Contract 2002*Size 1	0.106**	0.044	0.320***	0.105	0.317***	0.106
Size2	0.056	0.044	0.094	0.074	0.083	0.081
Contract 2002*Size 2	0.096***	0.035	0.228*	0.118	0.223*	0.119
Size3	0.118*	0.057	0.142	0.118	0.123	0.133
Contract 2002*Size 3	0.095**	0.038	0.258	0.180	0.239	0.190
Size4	0.232***	0.073	0.263**	0.116	0.253**	0.120
Contract 2002*Size 4	0.040	0.037	0.188	0.161	0.171	0.169
Operator's age	-0.005	0.006	-0.005	0.006	-0.007	0.010
Operator's age squared	0.00001	0.0001	-3.9 E-07	0.00006	0.00003	0.00012
Experience	-0.001	0.001	0.0002	0.001	-0.0005	0.0026
Inverse Mills ratio	—	—	—	—	0.117	0.372
State fixed effects	Yes	—	Yes	—	Yes	—
Adjusted R ²	0.77	—	0.77	—	0.77	—
Observations	4,525	—	4,525	—	4,525	—

Dependent variable: log head of hogs removed, 2007.

Notes: Asterisks denote significance at the *10%, **5%, and ***1% levels.

Source: Census of Agriculture, 2002, 2007.

OLS, ordinary least squares; IV-2SLS, instrumental variables two-stage least squares; SE, standard error.

of contracting on farm size for operations in size category 1, δ_2 measures the effect of contracting for operations in size category 2, and so on.

Results indicate that for continuing operations removing fewer than 5,000 head, production contract use in 2002 is associated with statistically significantly greater growth in farm size. Specifically, the use of a production contract was associated with an additional 10.6%, 9.6%, and 9.5% increase in output for farms in size groups one through three, respectively, compared with observationally similar farms that did not use a production contract. There is no statistically significant relationship between contract use and growth for farms removing at least 5,000 head in 2002.

Business Survival

Table 4 shows the survival rates for the independent and contract operations by farm-size category. The survival rates are lower than those reported for farms in other studies mainly because our definition of an exit includes operators who switched from finish hog production to another type of farming, as discussed in the

data section. The table illustrates a positive correlation between the survival rate and scale. In aggregate, survival rates are 17 percentage points higher for contract operations compared with independent operations. Also, the survival rate for contract operations is higher than for independent operations in each size category. However, this difference is only statistically significant for the smallest and largest farm-size categories. For the largest operations, the difference is substantial: 66% of contract operations survived in the hog business between 2002 and 2007 compared with only 54% of independent operations.

The same controls as the growth regressions are used to explain the likelihood of surviving in finish hog production (column 1, Table 5). Results indicate no statistically significant relationship between the use of production contracts and the likelihood of surviving for operations with fewer than 5,000 head. However, for operations removing at least 5,000 head, the use of a production contract in 2002 is associated with a large and statistically significant increase in the likelihood of surviving in the finish-only hog business between 2002 and 2007.

Table 4. Business Survival Rates by Initial Farm Size and Organizational Arrangement, 2002–2007

	Independent 2002	Contract 2002	Difference (contract – independent)	t-stat
Size 1 (100–999 head removed 2002)				
Survival rate, 2002–2007	0.218	0.282	0.063	3.81***
Observations	2,541	856		
Size 2 (1,000–2,499 head removed 2002)				
Survival rate, 2002–2007	0.404	0.429	0.025	1.29
Observations	1,431	1,199		
Size 3 (2,500–4,999 head removed 2002)				
Survival rate, 2002–2007	0.565	0.604	0.039	1.68*
Observations	779	1,036		
Size 4 (5,000+ head removed 2002)				
Survival rate, 2002–2007	0.539	0.655	0.116	5.93***
Observations	810	2,342		
All				
Survival rate, 2002–2007	0.353	0.523	0.170	18.20***
Observations	5,561	5,433		

Notes: Asterisks denote rejection of the null hypothesis that the difference in means is zero at the *10%, **5%, and ***1% statistical significance levels.

Source: Census of Agriculture, 2002, 2007.

Contract Adoption

Next, consider the effect of contract adoption on farm size growth for all continuing operations that did not have production contracts in

2002 (Table 6). Because none of the potential adopters had contracts in 2002, adopters are those with production contracts in 2007 and nonadopters are those without contracts in 2007. In aggregate, 16% of the sample adopted

Table 5. Hog Business Survival, 2002–2007

Variables	(1) OLS Regression		(2) IV-2SLS Regression	
	Parameter	SE	Parameter	SE
Intercept	−0.462**	0.223	−0.271***	0.081
Log head removed 2002	0.065***	0.009	0.064***	0.010
Contract 2002*Size 1	0.029	0.018	0.038	0.041
Size2	0.079***	0.020	0.076**	0.031
Contract 2002*Size 2	0.027	0.018	0.037	0.050
Size3	0.183***	0.028	0.137***	0.045
Contract 2002*Size 3	0.031	0.022	0.128**	0.061
Size4	0.099***	0.035	0.124***	0.044
Contract 2002*Size 4	0.103***	0.021	0.090**	0.043
Operator's age	0.007***	0.003	0.007***	0.003
Operator's age squared	−0.00011***	0.00002	−0.0001***	0.00002
Experience	0.002***	0.001	0.002***	0.001
Adjusted R ²	0.13		0.12	
Observations	10,994		10,994	

Dependent variable: survived as Hog Finish-only operation 2002–2007.

Notes: Asterisks denote significance at the *10%, **5%, and ***1% levels.

Source: Census of Agriculture, 2002, 2007.

OLS, ordinary least squares; IV-2SLS, instrumental variables two-stage least squares; SE, standard error.

Table 6. Change in Number of Head Removed for Potential Contract Adopters, 2002–2007

	Independent 2007 (nonadopter)	Contract 2007 (adopter)	Difference (contract – independent)	t-stat
Size 1 (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***
Average percent change	3.0	47.9	44.9	5.33***
Observations	468	54		
Size 2 (1,000–2,499 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***
Average percent change	-4.5	23.7	28.2	4.50***
Observations	446	86		
Size 3 (2,500–4,999 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*
Average percent change	-3.0	-3.0	-0.1	-0.01
Observations	341	66		
Size 4 (5,000+ 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
Average 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***
Average percent change	-1.3	14.3	15.6	4.56***
Observations	1,563	292		

Notes: Sample consists of operations that did not use a production contract in 2002 and that remained in business 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. 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.

a contract with the adoption rate increasing with farm size.⁹ There was a strong statistically significant correlation between contract adoption and farm growth: on average, adopters removed 918 more head, whereas independent operations removed 323 more. In terms of

average percent change, adopters grew in size by 14% and nonadopters shrank in size by 1%.

The aggregate difference between contract adopters and nonadopters is attributable mainly to differences among smaller scale operations. Among operations removing fewer than 1,000 head, adopters increased output by 663 more head than nonadopters, which is equivalent to a 45 percentage point difference in average percent change. For operations removing between 1,000–2,499 head, the absolute increase in scale was even larger (1,319 additional head removed), although as a proportion of output,

⁹Note that although 15.7% of the farms in the sample adopted a contract (Table 6), this corresponds to 14.7% of the population (Table 1). This difference results because all summary statistics were calculated using USDA–National Agricultural Statistics Service probability weights (see footnote 3 for more details).

Table 7. Contract Adoption and Farm Size Growth for Potential Contract Adopters

Variables	(1) OLS Regression		(2) IV-2SLS Regression		(3) IV-2SLS Regression	
	Parameter	SE	Parameter	SE	Parameter	SE
Intercept	0.514	0.319	0.739**	0.338	1.304**	0.526
Log head removed 2002	0.863***	0.034	0.826***	0.039	0.689***	0.105
Contract 2007*Size 1	0.525***	0.087	1.774***	0.544	1.960***	0.560
Size 2	0.027	0.059	0.163	0.115	0.127	0.118
Contract 2007*Size 2	0.340***	0.071	0.662	0.569	0.643	0.569
Size3	0.136	0.082	0.234	0.154	0.066	0.195
Contract 2007*Size 3	0.009	0.082	0.747	0.722	0.663	0.725
Size 4	0.251**	0.108	0.243	0.192	0.286	0.195
Contract 2007*Size 4	-0.083	0.082	1.103	0.740	0.984	0.745
Operator's age	0.015	0.010	0.008	0.010	-0.012	0.017
Operator's age squared	-0.0002	0.0001	-0.0001	0.0001	0.0002	0.0002
Experience	-0.005**	0.002	-0.004	0.002	-0.009*	0.004
Inverse Mills ratio	—	—	—	—	1.048	0.747
State fixed effects	Yes	—	Yes	—	Yes	—
Adjusted R^2	0.75	—	0.74	—	0.74	—
Observations	1,855	—	1,855	—	1,855	—

Dependent variable: log head of hogs removed, 2007.

Notes: Asterisks denote significance at the *10%, **5%, and ***1% levels. Potential contract adopters are operations that continued in business (2002–2007) but did not use a production contract in 2002. Production contract use in 2007 indicates contract adoption between 2002 and 2007.

Source: Census of Agriculture, 2002, 2007.

OLS, ordinary least squares; IV-2SLS, instrumental variables two-stage least squares; SE, standard error.

this additional growth was smaller (28 percentage points).

The effect of contract adoption for smaller scale operations remains statistically significant after controlling for initial farm size, age, experience, and state fixed effects using an OLS regression analysis (column 1, Table 7). With the controls, contract adoption is associated with a 52.5 percentage point increase in output for farms in the smallest size category and a 34 percentage point increase for farms initially removing 1,000–2,499 head.

Addressing Potential Sample Selection Bias

The IV-2SLS approach requires that the instrument (contract availability) be uncorrelated with the error terms in the outcome equations and strongly correlated with the endogenous variable (contract use/adoption). The statistical strength of the instrument is tested by estimating the first-stage equation (4) and computing the F-statistic for the null hypothesis that

the instrument coefficient is zero.¹⁰ A standard rule of thumb is that the F-stat should exceed 10; however, Stock and Yogo (2005) argue in the case of one instrument and one endogenous regressor, the F-statistic should exceed 16.¹¹

As expected, contract availability is strongly correlated with contract use in 2002 and with contract adoption between 2002 and 2007. As shown at the bottom of Table 8, for the three samples used in the analyses, the F-statistics for the contract availability coefficient are 801,

¹⁰ An F-test is used because the R^2 can be a misleading statistic for measuring the correlation between the instrument and the endogenous regressor. For example, if there are other variables in the first-stage regression (e.g., operator's age or experience) that are strongly correlated with the contracting decision, then one could obtain a high R^2 despite having a weak instrument.

¹¹ With instruments that are only weakly correlated with the variable they instrument for, the two-stage least squares estimator is biased toward the probability limit of the OLS estimator with the bias occurring because of randomness in the first-stage fitted values (Bound, Jaeger, and Baker, 1995).

Table 8. Instrumental Variables First-Stage Regressions

Variables	(1) Contract 2002		(2) Contract 2002		(3) Contract 2007	
	Parameter	SE	Parameter	SE	Parameter	SE
Intercept	-0.173	0.134	-0.194***	0.073	-0.210	0.182
Contract availability 2002	0.774***	0.027	0.773***	0.017	0.220***	0.042
Log head removed 2002	0.073***	0.015	0.069***	0.008	0.032	0.020
Size 2	0.027	0.026	0.038**	0.015	0.002	0.033
Size 3	0.021	0.035	0.040*	0.021	-0.033	0.046
Size 4	0.044	0.047	0.047*	0.027	-0.006	0.061
Operator's age	-0.007*	0.004	-0.006***	0.002	0.005	0.006
Operator's age squared	0.00008**	0.00004	0.0001***	0.00002	-0.0001	0.0001
Experience	-0.004***	0.0008	-0.004***	0.00048	-0.001	0.001
F-statistic ^a	801		1,986		27	
Adjusted R ²	0.28		0.31		0.04	
Observations	4,525		10,994		1,855	

Dependent variable: Contract 2002, Contract 2007.

^a The F-statistic corresponds to the test of the hypothesis that the instrument (contract availability 2002) is zero. Stock, Wright, and Yogo (2002) suggest that the F-statistic should exceed 10 for inference based on the two-stage least squares estimator to be reliable when there is one endogenous regressor.

Notes: Asterisks denote significance at the *10%, **5%, and ***1% levels. Samples for three first-stage regressions correspond to: 1) continuing operations; 2) all operations in business in 2002; and 3) potential adopters (continuing operations that did not use a production contract in 2002).

Source: Census of Agriculture, 2002, 2007.

SE, standard error.

1986, and 27, which allays concerns about a weak instrument. The instrument coefficients imply that a 1 percentage point increase in local contract availability in 2002 is associated with a 0.77 percentage point increase in the probability of using a contract and a 0.22 percentage point increase in the probability of adopting a contract.

As shown in the second set of results in Tables 3, 5, and 7, the IV-2SLS regressions produce broadly similar results to the OLS regressions with a few notable differences. In the farm growth analyses (Tables 3 and 7), the IV-SLS contract use/adoption coefficients are strongly statistically significant only for the smallest size category, and these IV-2SLS coefficients somewhat larger than those obtained using OLS. For farms removing fewer than 1,000 head, the IV-2SLS coefficients indicate that contract use results in 32 percentage points more output (Table 3), whereas contract adoption results in 177 percentage points more output than would have occurred had the operator not started to contract (Table 7).

The fact that the IV-2SLS coefficients are larger than the OLS coefficients suggests that small-scale contract users/adopters are

fundamentally different (in unobservable ways) from small-scale independent producers, and these unobservables cause the OLS coefficient to be biased downward. One possible explanation for this bias is that farmers who would have expanded more (with or without a contract) were less likely to use or adopt a contract, perhaps because they already had access to financing and did not need the additional collateral that a production contract might provide. In contrast, farmers who would have grown less (with or without a contract) over the next 5 years were more likely to use or adopt a contract. The lack of strong statistical significance for contract use/adoption for farms that removed more than 1,000 head suggests that this possible explanation does not apply to larger farms.

Finally, the potential selection bias from sample attrition was addressed in the farm-size regressions using the two-step Heckman procedure (the third set of regressions in Tables 5 and 7). Results indicate the inverse Mills ratio (IMR) parameter is not statistically significantly different from zero in either regression. Hence, there is no evidence that sample attrition biased the results of the IV-2SLS estimates (the second

set of regressions in Tables 5 and 7). There were no substantial differences between the estimated coefficients for the models with the IMR to those without the IMR.

Conclusion

This article explores empirically whether production contracts have facilitated the growth and survival of U.S. hog operations. The study takes advantage of recently collected information from the Census of Agriculture that permits comparison between independent and contract producers over time. Findings indicate that production contract use was associated with greater subsequent farm size growth for relatively small-scale operations (those removing fewer than 1,000 head). Findings also indicate that small-scale independent operators who adopted a contract expanded production much more than similar operators who remained independent.

It is possible that production contracts, by reducing input expenditures for growers, allowed small-scale operators to “leverage” their financial resources and thereby operate at a larger scale. It is also possible that adopting a production contract allowed small-scale producers to obtain more credit for facility expansion than they would have been able to otherwise. Banks might be willing to lend more to operators having a production contract because a contract substantially reduces farm income risk. Alternatively, contracts might facilitate the transfer and adoption of new production technologies that allow smaller operations to grow by producing more efficiently and profitably.

On the other hand, results indicate that the use of a production contract was not strongly associated with hog business survival for operations producing fewer than 5,000 head. This suggests that small- and medium-scale contract producers have a similar propensity to exit the hog business as do independent operations of the same size. It is possible that although operators with production contracts face less price risk, they are more highly leveraged (at a given farm size) because contracts have allowed them to take on relatively more debt, which makes them vulnerable to production shocks.

The study found that production contracts influence farm structure in substantially different ways for very large-scale operations (those with more than 5,000 head). For these large farms, neither contract use nor adoption was associated with an increase in the scale of production. It is likely that beyond a certain size, economies of scale in hog production are limited (Key, McBride, and Mosheim, 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 large-scale operators who use a production contract have a greater probability of surviving in the hog business than similar operators who do not contract. This suggests a compelling motivation for operators of large hog farms to adopt a production contract, as 28% of the large-scale potential adopters did between 2002 and 2007.

In sum, the findings suggest that the widespread use of production contracts may have contributed to the recent consolidation of production in the hog sector by allowing some smaller operations to grow more than they would have otherwise and by helping some large farms to remain in business longer. Although there are numerous factors contributing to the consolidation of production in the hog sector, the results suggest that efforts to regulate or limit the use of contracts could have important implications for farm growth and survival.

[Received September 2012; Accepted December 2012.]

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