Have Hog Producers with Production Contracts Maintained an Economic Advantage of Independent Hog Producers in Recent Years?

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Abstract

Preliminary estimates of technical efficiency based on USDA data for 1997 through 2001 indicate that independent operations were significantly more efficient than contract operations. Preliminary estimates also indicate that both types of operations exhibited increasing returns to scale with contract operations appearing to exhibit significantly higher returns to scale than independent operations, but that larger contract and independent operations exhibit roughly comparable returns to scale. Our estimates of excess nutrients that derive from both commercial fertilizer and manure, comparing the performance of production contract operations and independent operations indicate that, in general, levels of excess nutrients per acre of land are significantly higher on contract operations than independent operations. The results suggest that adjusting the performance measures to include excess nutrients as a "bad output" would tend to favor independent producers over contract operations compared to performance measures that ignore pollution.

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Introduction

The growing importance of production contracts in hog production suggests large economic benefits and/or reduced risk accrue to farmers participating in production contracts (see Figure 1). The rapid growth in contracting has led to heightened concerns about the impacts of increasing concentration on farm structure and the health of the rural economy. It has also led to efforts by various levels of government to regulate contract production. Recent research suggests that production contracts in hog production are associated with a substantial increase in productivity representing a technological improvement over independent production as described in Key and McBride (2002) for hog production in 1998. This implies that efforts to regulate contracting operations may have large economic costs. However, recent consolidation trends in the hog sector may have altered the relative economic performance of independent versus contract operators.

Preliminary estimates of technical efficiency based on USDA data for 1998 through 2001 indicate that while independent operators were much less technically efficient than contract operations in 1998 and 1999, they were more efficient or nearly as efficient as contract operations in 2000 and 2001. Using a Cobb-Douglas specification we estimate that the mean technical efficiency score[1] for contract operations in 1998 is 0.83 compared to 0.67 for independent operations. Similarly, in 1999 we find that contract operations achieved mean technical efficiency scores of 0.85 compared to 0.71 for independent operations. But we also find a significant narrowing in the advantage of contract farmers over independent operations in Iowa, the major hog producer. In contrast to the 1998 and 1999 results, we find that independent hog operations outperformed contract operations with technical efficiency scores of 0.68 compared to 0.63 in 2000, while in 2001, we again find that contractors are more efficient with a score of 0.72

1 Technical efficiency represents the ratio of current to maximum possible or “best practice” production. Technical efficiency scores

compared to 0.64, but not by nearly as wide a margin as in 1998 and 1999. The technical efficiency comparisons of independent operations with contract operations suggest a possible narrowing of the competitive advantage of contract farms over independent farms between 1998 and 2001. This may be because of the exit from agricultural production of many independent operations, who were likely much less efficient than the survivors. For example, between 1997 and 2001 the number of operations raising hogs in Iowa dropped from 18,000 to 10,500, while the proportion of hog numbers on operations with fewer than 1000 hogs dropped from 37 percent to 15 percent (USDA 2002, 1998). Since independents represent the majority of operations reporting it is clear that the scale of production on surviving independents increased sharply between 1997 and 2001.

These results suggest that the Key and McBride study may overemphasize the role of technological improvements of contracted production over independent production in the rapidly changing hog sector. Several major questions then arise. How important is the role of risk reduction in contracting hog production ? How important is the role of scale in contracting hog production? Has the pace of contract production abated in regions where remaining independent operations are technically and scale efficient? Finally, does regulating contract production in this changed economic environment involve large economic costs, particularly if the impacts of pollution are included—i.e does contracted production and independent production involve the same pollution risks ?

In this study, we do two things: 1) develop farm level estimates of excess nutrients that derive from both commercial fertilizer and manure, comparing the performance of production contract operations and independent operations, and 2) calculate farm-level efficiency scores (performance measures of economic activity) and assess economies of scale for farms involved in production contracts and independent farms using a multi-output, multi-input model. We construct a panel data set of farms for 1997 and 2001 based on pseudo cohorts and derive measures of efficiency and returns to scale. The analysis uses five years (1997-2001) of USDA's Agricultural Resource Management Survey (ARMS) data, incorporating both

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may range from zero to one.

1)whole farm data, including income and operator characteristics, and 2) hog production practices and cost data. Finally, we infer the relative risk of water pollution based on these findings, recognizing that pollution risk may vary by climate and soil type. This study focuses on farms producing hogs for slaughter from independent and contracting operations. And, we focus only on production contracts, and ignore marketing contracts.

Model

We use a multi-input distance function and stochastic frontier and inefficiency procedures to estimate efficiency scores, assess factors influencing efficiency, and estimate returns to scale. The input distance function permits a multi-input, multi-output technology without requiring observations on output and input prices as described by Coelli and Perelman (1996, 2000). In contrast to a cost or profit function, the input distance function does not require a system of equations in the estimation procedure. The input distance vector considers how much the inputs may be proportionally contracted with outputs held fixed. In this sense it implies cost minimization. The appropriate functional form is ideally flexible, easy to calculate, and permits the imposition of homogeneity. Following Coelli and Perelman, we use stochastic production frontier (SPF) measurement to econometrically estimate the input distance function DI(X,Y,R), after implementing theoretically required regularity conditions, making a functional form assumption, and specifying a stochastic structure allowing for both a "white noise" error and a one-sided error representing deviations from the production frontier. Writing the distance function accordingly, assuming it can be approximated by a translog functional form to limit a priori restrictions on the relationships among arguments of the function, we obtain:

(1a) $\ln D^I_{it}/X_{1,it} = \alpha_0 + \Sigma_k \alpha_k \ln X^*_{kit} + 0.5\, \Sigma_k \Sigma_l \beta_{kl} \ln X^*_{kit} \ln X^*_{lit}$

$+ \Sigma_m \alpha_m \ln Y_{mit} + 0.5\, \Sigma_m \Sigma_n \alpha_{mn} \ln Y_{mit} \ln Y_{nit} + \Sigma_k \Sigma_m \varphi_{km} \ln Y_{kit} \ln X^*_{mit}$, or

(1b) $-\ln X_{1,it} = \alpha_0 + \Sigma_k \alpha_k \ln X^*_{kit} + 0.5\Sigma_k \Sigma_l \beta_{kl} \ln X^*_{kit} \ln X^*_{lit}$

$+\Sigma_m\alpha_m \ln Y_{mit} + 0.5\Sigma_m \Sigma_n \alpha_{mn} \ln Y_{mit} \ln Y_{nit} + \Sigma_k \Sigma_m \varphi_{km} \ln Y_{kit} \ln X^*_{mit} - \ln D^I it$, where i denotes the ith farm, m,n the outputs, k,l the inputs, and t, time period. More precisely, X^*_{lit} represents the lth input divided by land so that the specification is essentially specified on a per land basis, which seems reasonable as we often interpret farm production and productivity per unit of land. This functional relationship, which embodies a full set of interactions among the X and Y arguments of the distance function, can be more compactly written as $-\ln X_{1,it} = TL(X/X_1,Y,t) = TL(X^*,Y,t)$. We append a symmetric error term, v to equation (1b) to account for noise, and also change the notation "$- \ln D^I it$" to "u". The resulting $-\ln X_{1,it} = TL(X^*,Y) + v - u$ function (with the sub-scripts suppressed for notational simplicity) may be estimated by maximum likelihood (ML) methods, to impute the TE measures as the distance from the frontier. In addition to land the X_{it} represent expenditures on five other inputs: labor, fuel, fertilizer and other chemicals, miscellaneous operating expenses, and capital services. Our outputs are revenue from corn, soybeans, other crops, and livestock (i.e. hogs and other livestock).

It is assumed that the inefficiency effects are independently distributed and U_i arises by truncation (at zero) of the normal distribution with mean μ, and variance s^2, where μ_I is defined by

$$(2)\quad \mu_i = \delta_0 + \delta_1 pmark + \delta_2 acres + \delta_3 age + \delta_4 education + \delta_5 rent + \delta_6 debt + \delta_7 biocorn + \delta_8 biosoybeans + \delta_9 off\text{-}farm + \delta_{10} excessn + \delta_{11} excessp + \delta_{12} cohortsmall + \delta_{13} cohortlarge$$

where pmark represents the proportion of operations that sell slaughter hogs under a production contract, acres is a continuous variable representing acres per farm, age represents the age of the operator, education represents the education score for the operator (where 1=less than high school, 2=high school diploma, 3=some college, 4=BA or BS degree, and 5=graduate school), rent represents the ratio of acres rented to total acres operated, debt represents the debt/asset ratio, biocorn represents the proportion of corn acres in GMO corn, biosoy represents the proportion of soybean acres in GMO soybeans, off-farm represents the ratio of off-farm earnings to farm earnings, excessn represents the amount of excess nitrogen per acre operated after accounting for all nitrogen credits and uptake of nitrogen by crops, excessp represents the amount of excess phosphorous per acre operated after accounting for all phosphorous credits and after uptake of phosphorous by crops, cohortsmall represents the dummy for small and medium commercial and residential farms, and cohortlarge represents a dummy for very large family farms and nonfamily farms. All continuous variables (that is, all of the inefficiency effects except for the cohort dummies and pmark) are in logs.

The maximum-likelihood estimates for the parameters of the stochastic frontier model defined by equations (1b) and (2) were estimated using FRONTIER Version 4.1 (Coelli). . For the SPF model -u thus represents inefficiency; the efficiency scores generated by FRONTIER essentially measure exp(-U) = DI(X*,Y,R). This is therefore our measure of technical efficiency.

The expected signs on the coefficients for acres, rent, bicorn, and biosoy, are negative, signifying that these variables are likely to be negatively related to inefficiency and positively related to efficiency. Similarly, the expected signs on the coefficients for age, debt, and off-farm are likely to be negative. The expected coefficients for education, excessn, excessp are ambiguous. The coefficients on excessn and excessp are ambiguous because it is unclear whether larger operations with relatively more livestock, and hence more excessn and excessp are likely to be more technically efficient on average than large grain farms with relatively little excessn and excessp. The coefficient for off-farm is likely to be positive because we have not included off-farm income as an output. Nor have we included off-farm hours worked as part of the wage bill. Thus, in our model, off-farm is likely to be positively related to inefficiency and hence, negatively related to efficiency, because time spent in off-farm employment negatively influences the quality and availability of on-farm employment. The expected sign on pmark is ambiguous given the evidence for 1998-2001 on the comparison of technical efficiency scores for independent and contract operations cited above. Further our analysis incorporates data for 1997, for which we have not calculated a comparison of the technical efficiency scores of independent operations compared to contracting operations.

The SPF-based scale economy measure may also be computed from the estimated model via derivatives or scale elasticities: $-,_{DIY} = -,_m \partial \ln D^I(X,Y,t)/\partial \ln Y_m = ,_{X1Y}$ for M outputs Y_m. This measure is based on evaluation of (scale) expansion from a given input composition base.

Nutrient Balance Use

We develop farm-level estimates of excess nitrogen (phosphorus) from commercial fertilizer and manure sources for hog producing states, including Southern, Eastern, and Western states as well as those in the Corn Belt. At the national level we see that between 1994/95 and 2001 the share of the value of production under contract for hogs doubled to 60 percent as shown in figure 1. In Figure 2 we see that the majority of specialized hog Agricultural Statistics Districts in the United States are located in the Corn Belt, North Carolina, and Oklahoma.

In addition to hogs, cattle, dairy, and poultry are major sources of manure in these states. Using hogs as an example, in corn producing states we see that hog output per farm, measured as value of production adjusted for inflation, increased dramatically between 1995 and 2000 (USDA Costs and Returns data). In the states intensively surveyed (Illinois, Indiana, Iowa, and Minnesota, each with 50 or more observations in each time period) hog output per farm increased dramatically—276 percent in Illinois, 202 percent in Iowa, and 185 percent in Minnesota. Only Indiana showed no appreciable growth in hog output per farm. In the less intensively surveyed states, (Michigan, Nebraska, Ohio, South Dakota, and Wisconsin) the data also suggest large increases in output per farm. In the thinly surveyed states (Kansas and Missouri) there was little increase in output per farm. Changes in concentration in other species were mixed during 1996-2001. USDA data indicate close to a 200 percent increase in cattle output per farm in Kansas and South Dakota but only small increases in dairy output per farm in the key dairy states of Michigan, Minnesota, and Wisconsin. Poultry output per farm increased nearly 200 percent for the major corn producing states, but concentrations by state cannot be identified from the available USDA data.

Excess nitrogen (phosphorus) is defined as the difference between the amount of nitrogen (phosphorus) applied from all sources (chemical fertilizers plus soybean, legume and/or manure credits) and the amount of nitrogen (phosphorus) removed during the crop production process. To calculate excess nitrogen and phosphorous at the farm level, we employ well-known nutrient balancing techniques.

Data

Our approach uses U.S. farm level data from the 1997-2001 Agricultural Resources Management Study (ARMS) surveys. ARMS is an annual survey covering farms in the 48 contiguous states, conducted by the National Agricultural Statistics Service and the Economic Research Service. All hog-producing states represented in ARMs phase III surveys were selected. In order to allow inferences to the state and regional level we use weighted observations. In general, observations in each of the years analyzed included more than twenty hog- producing states. IL, IN, IA, MN, NC, NE, and OH were considered as individual states. Observations in Michigan and Wisconsin were considered as one eastern Lake state. Observations in North Dakota and South Dakota were considered as one upper Northern Plains state. Observations in DE, ME, MD, NH, NJ, NY, PA, RI, VA, and WV were considered as one eastern state. Observations in AL, AR, FL, GA, KY, LA, MO, SC, TN, and TX were considered as one southern state, and observations in CO, ID, KS, OK, OR, WA, and WY were considered as one western state. Hence, we used 12 “states” or regions in the anlaysis.

Four outputs are included in the model estimation. The crop outputs consist of corn, soybeans, and other crops, measured as the total value of production of each. Livestock production is measured as the total value of livestock production. For the variable inputs, labor costs are the annual per-farm expenditures on labor; energy is expenditures on gasoline, diesel fuel and other fuels; fertilizer is expenditures on fertilizer, lime and other chemicals; and materials is expenditures on seed, feed and miscellaneous operating expenses. Capital machinery is measured as the annualized flow of capital services from assets (excluding land). Our land variable is an annualized flow of services from land and is constructed as an annuity based on a 20-year life and 10 percent rate of interest.

To support empirical production studies using panel data, the temporal pattern of a given farm’s production behavior must be established. In the absence of genuine panel data, repeated cross-sections of data across farm typologies may be used to construct a pseudo panel data (see Deaton, Heshmati and Kumbhakar, Verbeek and Nijman) The pseudo panels are created by grouping the individual observations into a number of homogeneous cohorts, demarcated on the basis of their common observable timeinvariant characteristics, such as quality of land as determined by geographic location and size of farm as determined by the gross value of sales. The subsequent economic analysis then uses the cohort means rather than the individual farm-level observations.

Farm-level data were assigned to cohorts by typology, (and sub typology), by gross value of sales, by state, and by year for the hog-producing states, generally following ERS farm typology groups (as they are divided by gross value of sales) described in Table 1. Cohort 1 is represented by hog farms with gross value of sales of less than $100,000. Cohort 2 is represented by hog farms with gross value of sales of $100,000 to $249,999. The largest cohort, cohort 7, represents hog farms with gross value of sales of greater than $1,000,000. Altogether, we form seven cohorts, which are delineated by gross value of sales as shown in Table 2. The resulting panel data set consists of 7 cohorts for each of 12 states, for 1997-2001, measured as the weighted mean values of the variables to be analyzed. In total we have 420 annual (cohort) observations (84 per year, a balanced panel), summarizing the activities of 517 farms in 1997, 1954 in 1998, 530 in 1999, 342 in 2000 and 326 in 2001. To translate these nominal values into real terms for the panel data, all variables are deflated by the estimated increase or decrease in cost of production in 1998, 1999, 2000, and 2001 compared to 1997 (in terms of agricultural prices).

A summary of the sample data used in the output distance function estimations is presented in Table 3 for 2000. The average farm size varies from 95 acres in the limited resource typology to 8,796 acres on the very large family farm typology. Excess nitrogen at close to 40 pounds per acre operated and excess phosphorous at close to 30 pounds per acre operated are highest nonfamily farms. The average age of farmers is highest in retirement and low sales typologies, and lower in the residential and higher sales farm typologies. The farmer education average of 2.45 is between a high school diploma (2) and some college (3), and tends to be slightly greater in the high sales typologies.

Input distance function results

The maximum-likelihood (ML) estimates of the parameters of the output distance stochastic production frontier are presented in Table 4. Given the pseudo-cohort nature of the data, cohort dummies are added to take account of cohort-specific effects (Heshmati and Kumbhakar). Close to 80 percent of the coefficients of the model are significant at the 10 percent level or better. The estimate of the variance parameter, ? (where ? =$F_U^2/(F_V^2 + F_U^2)$, is also significantly different from zero, which implies that the inefficiency effects are significant in determining the level and variability of output of farmers in the corn states analyzed.

Turning to the factors influencing efficiency, we find that the coefficient on *pmark* is positive and significant, indicating that the variable representing the proportion of contract production is positively associated with technical inefficiency and, therefore, negatively associated with technical efficiency. Similarly, we find that the coefficient on *acres operated* is negative and significant, indicating that the size effect is negatively associated with technical inefficiency and, therefore, positively associated with technical efficiency, confirming our hypothesis. Among the other factors influencing efficiency we find that the coefficients on acres rented, education, and biosoy are significant and also positively influence the efficiency frontier. In contrast, we find that the coefficients on age, biocorn and excess nitrogen are significant but negatively influence the efficiency frontier. And, we find that the ratio of off-farm earnings to farm earnings to be significantly related to technical inefficiency. This is surprising given the focus on farms producing corn.

Using the coefficients found in Table 4, an increase in farm size of 10 percent would increase the efficiency of production on the corn farms analyzed by 4.6 percent. Similarly, an increase in rented land of 10 percent would increase efficiency by about 2.4 percent.

We find the mean technical efficiency score for all farmers is 0.800. This set of results implies that our sample of farms could reduce their inputs by about 20 percent without compromising output if they could achieve best management practices by producing on the frontier. Our preliminary estimate of returns to scale is 0.65, i.e. hog farms, on average, exhibit increasing returns to scale. We also find that independent operations exhibit significantly lower returns to scale than contract operations, 0.63 compared to 0.71, indicating that contract operations are, on average, slightly more scale efficient than independent operations; that is, independent operations are, on average relatively too small. The t-test for the comparison of means of the two groups is 3.33. More interestingly, the returns to scale are roughly comparable for the largest 50 percent of contracting operations (ranked by level of livestock output) compared to the 50 percent of independent operations—0.77 versus 0.73. In contrast, the returns to scale of the lowest 50 percent of contracting operations ranked in terms of livestock output are estimated at 0.67 compared to only 0.48 for the smallest 50 percent of independent operations.

Nutrient Balance Results

We find that excess nitrogen and phosphorous levels per acre operated appear to have remained fairly constant during the period of analysis. Based on the USDA survey data analyzed, average excess nitrogen (phosphorous) per acre operated hovered at close to 30 (20) pounds during 1997-2001. We also find that excess nutrient levels are generally significantly higher on contract operations than on independent operations. For example, in 1999, contract operations exhibited 48.32 pounds of excess nitrogen compared to 26.32 pounds on independent operations. The t-test for the comparison of means for the two excess nitrogen groups is 2.46. Similarly, contract operations in 1999 exhibited 42.03 pounds of excess phosphorous compared to 17.84 pounds on independent operations. The t-test for the comparison of means for the two excess phosphorous groups is 2.85. As shown in Table 5 contract operations exhibited significantly more excess nitrogen per acre operated than independent operations in 2000 and 1999 and significantly more excess phosphorous than independent operations in all years analyzed except 1997.

Summary and Conclusions

Preliminary estimates of technical efficiency based on USDA data for 1997 through 2001 indicate that independent operations were significantly more efficient than contract operations. Preliminary estimates also indicate that both types of operations exhibited increasing returns to scale with contract operations appearing to exhibit significantly higher returns to scale than independent operations. The returns scale results suggest that small independent operations, in particular, are too small to be economically competitive. Our estimates of excess nutrients that derive from both commercial fertilizer and manure, comparing the performance of production contract operations and independent operations, indicate that, in general, levels of excess nutrients per acre of land are significantly higher on contract operations than independent operations. The results suggest that adjusting the performance measures to include excess nutrients as a “bad output” would tend to favor independent producers over contract operations compared to performance measures that ignore pollution.

In future research it would be desirable to assess costs of production by type of operation. Our preliminary results suggest feed costs, in particular may differ significantly by type of operation. Finally, additional data available in 2002, likely to include many more hog observations than 2000 and 2001 because it is a census year, could strengthen the results.

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Table 1. The Farm Typology Groups

Small Family Farms (sales less than $250,000)

1. **1. Limited-resource.** Any small farm with: gross sales less than $100,000, total farm assets less $150,000, and total operator household income less than $20,000. Limited-resource farmers may report farming, a nonfarm occupation, or retirement as their major occupation

2. **2. Retirement.** Small farms whose operators report they are retired (excludes limited-resource farms operated by retired farmers).

3. **3. Residential/lifestyle.** Small farms whose operators report a major occupation other than farming (excludes limited-resource farms with operators reporting a nonfarm major occupation).

4. **4. Farming occupation/lower-sales.** Small farms with sales less than $100,000 whose operators report farming as their major occupation (excludes limited-resource farms whose operators report farming as their major occupation).

5. **5. Farming occupation/higher-sales.** Small farms with sales between $100,000 and $249,999 whose operators report farming as their major occupation.

Other Farms

6. Large family farms. Sales between $250,000 and $499,999.

7. Very large family farms. Sales of $500,000 or more

8. **8. Nonfamily farms.** Farms organized as nonfamily corporations or cooperatives, as well as farms operated by hired managers

Source: U.S. Department of Agriculture, Economic Research Service

Table 2. Group Definitions by Agricultural Statistics Districts Groupings

Cohort	***GV Sales***
COH1	<100,000
COH2	100,000-249,999
COH3	250,000-324,999
COH4	325,000-499,999
COH5	500,000-749,999
COH6	750,000-999,999
COH7	>1,000,000

Table 3: Summary Statistics for Selected Variables in Hog States, 2000

Type	Farms (%)	Corn	Soybeans	Excess Nitrogen	Excess Phos	Livestock	labor	Acres	Age	Educ.
		--- dollars -------		---# per acre------		--Dollars per farm--				
Limited Resource	1.0	14,183	9,113	32.91	15.63	15,764	27,646	202	37.99	1.64
Retirement	1.9	0	0	0	0	10,363	16,796	156	67.67	1.00
Residental/ lifestyle	21.8	2,988	3,476	23.87	15.91	26,937	16,755	95	47.27	2.67
Farming/ lower sales	21.4	9,784	9,857	11.93	7.70	32,310	30,750	460	53.60	2.16
Farming/ higher sales	23.5	27,570	26,880	24.38	16.68	87,756	33,945	633	48.02	2.28
Large family farms	16.6	43,794	44,837	21.82	19.72	239,585	37,884	800	46.57	2.84
Very Large Family Farms	12.5	59,410	72,874	4.10	3.48	904,917	74,516	8,796	47.20	2.63
Nonfamily Farms	0.9	39,397	78,875	37.71	30.55	602,123	52,393	887	49.98	3.67
All Farms	100.0	26,772	7,170	25.41	18.90	189,617	34,994	718	52.05	2.47

Table 4. Input Distance function Results

Variable	Parameter	t-test	Description of variable
α_0	12.740	(11.48)	constant
α_{XF}	0.030	(0.15)	fertilizer
α_{XL}	-1.162	(4.71)	labor
α_{XE}	0.115	(1.48)	fuel
α_{XM}	0.162	(1.34)	feed or miscellaneous
α_{XK}	-0.614	(5.25)	capital
α_{Y1}	-0.450	(4.92)	corn output
α_{Y2}	-0.286	(0.28)	soybean output
α_{Y3}	0.174	(2.47)	other crop output
α_{Y4}	-0.707	(4.64)	livestock output
β_{XF*XF}	-0.032	(3.03)	fert*fert
β_{XL*XL}	0.054	(1.63)	labor*labor
β_{XE*XE}	0.001	(0.34)	fuel*fuel
β_{XM*XM}	-0.067	(2.71)	feed*feed
β_{XK*XK}	-0.081	(4.69)	capital*capital
α_{Y1*YI}	0.034	(4.86)	corn*corn
α_{Y2*Y2}	0.012	(3.93)	soybeans*soybeans
α_{Y3*Y3}	0.047	(5.74)	other crops*other crops
α_{Y4*Y4}	0.047	(7.20)	livestock*livestock
α_{Y1*Y2}	0.005	(1.49)	corn*soybeans
α_{Y1*Y3}	-0.006	(1.66)	corn*other crops
α_{Y1*Y4}	0.026	(3.30)	corn*livestock
α_{Y2*Y3}	0.001	(0.23)	soybeans*other crops
α_{Y2*Y4}	-0.014	(1.80)	soybeans*livestock
α_{Y3*Y4}	-0.020	(4.09)	other crops*livestock
β_{XF*XL}	-0.028	(1.46)	fert*labor
β_{XF*XE}	-0.016	(2.01)	fert*fuel
β_{XF*XM}	-0.023	(1.15)	fert*feed
β_{XF*XK}	0.046	(2.30)	fert*capital
φ_{XF*Y1}	0.033	(3.18)	fert*corn
φ_{XF*Y2}	-0.039	(3.23)	fert*soybeans
φ_{XF*Y3}	0.019	(2.31)	fert*other crops
φ_{XF*Y4}	-0.029	(2.06)	fert*livestock
β_{XL*XE}	-0.040	(2.67)	labor*fuel
β_{XL*XM}	-0.093	(1.99)	labor*feed
β_{XL*XK}	0.093	(2.28)	labor*capital
φ_{XL*Y4}	0.077	(3.73)	labor*livestock
β_{XE*XM}	0.038	(3.14)	fuel*feed
β_{XE*XK}	-0.001	(0.15)	fuel*capital
φ_{XE*Y4}	-0.016	(2.26)	fuel*livestock

Table 4. Input Distance function Results (continued)

Variable	Parameter	t-test	Description of Variable
β_{XM*XK}	0.094	(2.62)	feed*capital
φ_{XM*Y1}	-0.028	(3.13)	feed*corn
φ_{XK*Y2}	0.046	(4.63)	capital*soybeans
α_{1997}	-0.007	(0.21)	
α_{1998}	0.106	(2.61)	
α_{1999}	0.133	(3.08)	
α_{2000}	0.210	(4.54)	
α_{2001}	-0.211	(3.35)	
δ_{0}	0.527	(2.91)	
$\delta_{contract}$	0.961	(9.26)	
δ_{acres}	-0.464	(6.02)	
δ_{AGE}	0.561	(3.43)	
δ_{ED}	-0.443	(1.76)	
δ_{DEBT}	0.049	(0.87)	
δ_{RENT}	-0.235	(4.57)	
$\delta_{BIOCORN}$	0.129	(2.63)	
δ_{BIOSOY}	-0.076	(1.65)	
$\delta_{OFF-FARM}$	0.108	(2.51)	
δ_{XN}	-0.117	(2.54)	
δ_{XP}	-0.008	(0.13)	
$\delta_{cohort2}$	-0.013	(0.18)	
$\delta_{cohort3}$	0.262	(1.87)	
δ^{2}	0.094	(9.21)	
γ	0.736	(21.10)	
Log-liklihood	239.159		

Table 5. Nutrient Balance Comparisons 1997-2001

Year	Independent Operations	Contracting Operations	t-test
	---pounds per acre operated----------		
2001			
Excess N	22.79	28.52	0.52
Excess P	16.79	29.90	1.92
Obs	249	66	
2000			
Excess N	24.31	37.59	1.77
Excess P	17.87	30.16	3.04
Obs	276	66	
1999			
Excess N	26.33	48.32	2.46
Excess P	16.79	29.90	2.84
Obs	455	75	
1998			
Excess N	25.56	31.26	1.11
Excess P	18.67	30.92	3.32
Obs	1698	256	
1997			
Excess N	34.30	28.36	-1.12
Excess P	25.20	22.24	1.03
Obs	438	79	

Figure 1.

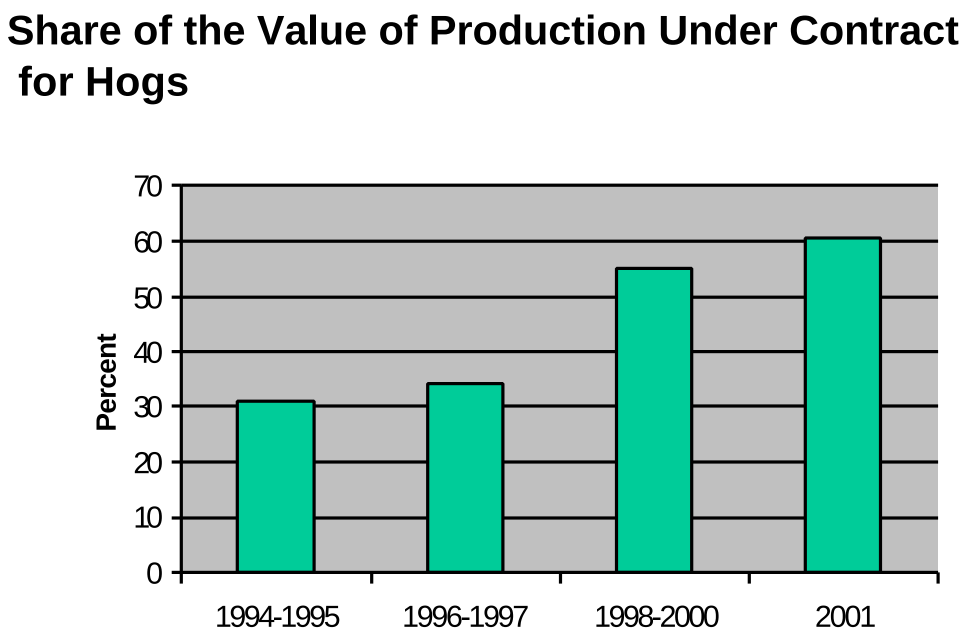
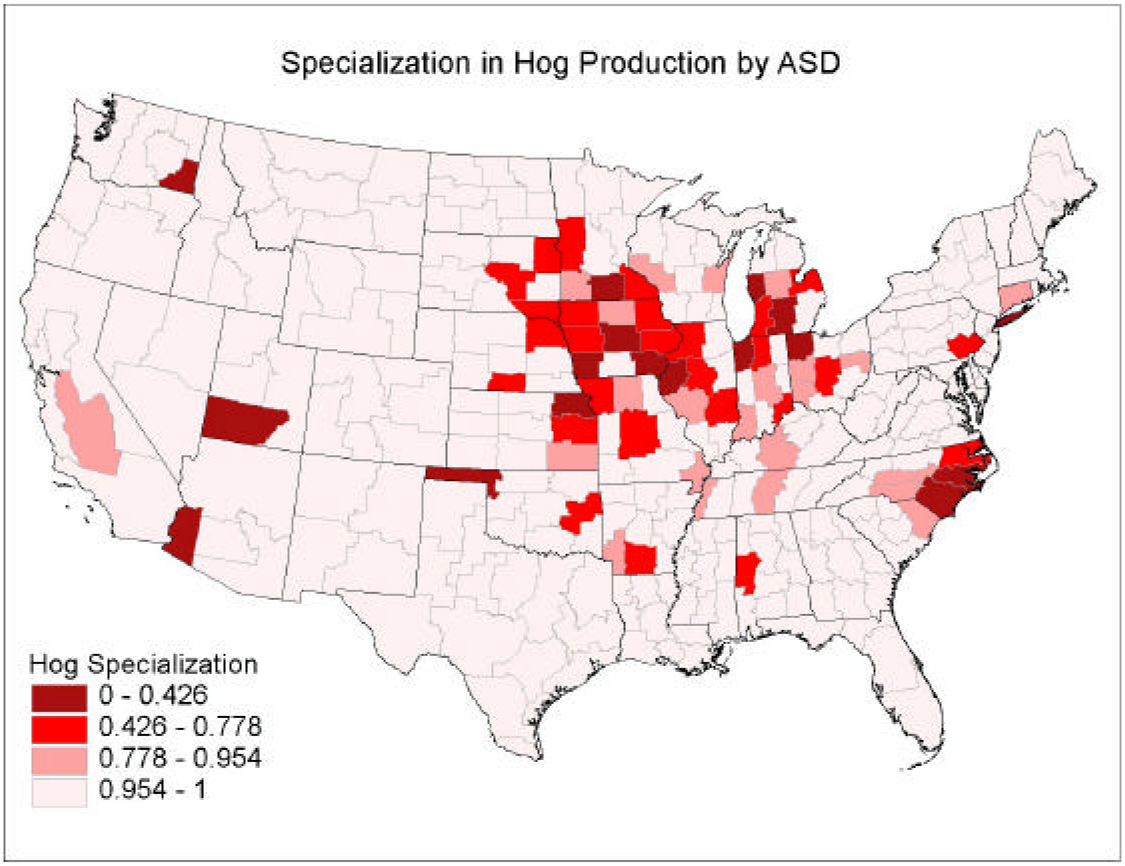

Share of the Value of Production Under Contract
for Hogs
Percent
70
60
50
40
30
20
10
0
1994-1995
1996-1997
1998-2000
2001

Figure 2. Hog States Surveyed*



*ASD (Agricultural Statistics District)
*Total value of livestock-value of hog production/total value of livestock, where zero indicates 100 percent specialization.