What Drives Agricultural Profitability in the U.S.:
Application of the DuPont Expansion Method

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1. Introduction

Recent changes in the agricultural sector have focused increased attention on the role of agricultural specialization and integration in the sector. The received doctrine from Adam Smith is that specialization allows producers to gain production economies. Current trends in agriculture tend to support this revealed doctrine. The parochial picture of the family farm with livestock and a vast array of crops have been replaced with commercial enterprises focusing on the production of a limited combination of commodities. This specialization has been associated with increased size both in terms of land and equipment. However, this specialization comes at a cost, at least for crop farms. The combination of specialized equipment and single crops implies that equipment and labor are only used for limited time periods during the year. The classic case that an expensive combine sits in the barn for all but three weeks on a large corn farm implies that the effective cost of machinery is much higher under specialized crop farms than for farms with more diversified production.

In addition to the notions of specialization, vertical integration in the farm sector has become an important theme over the past twenty years. The move toward vertical integration is probably more pronounced in the areas of livestock production, but vertical integration has also become important in some crops such as sugarcane. Economic theory suggests several causes for vertical integration. Joskow (2006) reviews alternative economic theories of vertical integration. Coase (1937) and Williamson (1979) suggest that vertical integration is a direct result of transaction costs. Grossman and Hart (1986) and Anderlini and Felli (2006) continue the theme, but refocus the discussion of transaction cost of specific investments. This recasts the discussion in terms of the hold-up problem and principal agent theory.

In order to examine the significance of specialization and vertical integration on domestic agriculture, this study uses a financial approach based on the DuPont expansion (Reilly and Brown, 2000). The traditional DuPont Expansion decomposes the rate of return to equity into asset efficiency, gross margins, and solvency. In the current study, we hypothesize that agricultural specialization directly affects the asset efficiency and gross margin of the farm. Specifically, specialization would tend to decrease asset efficiency while increasing the gross margin. On the other hand, vertical integration may affect the gross margin and solvency directly. The effect on solvency would result from the integrator's use of credit as an incentive. However, the general type of agricultural enterprise integrated may also have implications for asset efficiency. Specifically, livestock operations may tend to have greater asset efficiency than crops. Further, we hypothesize that acres operated by the firm may lead to a scale effect (Kislev and Peterson, 1982; Cochrane, 1979).

The objective of this paper is to examine the significance of specialization and vertical integration on the profitability (rate of return on equity, or ROE) in U.S. agriculture. We estimate a system of equations in log space using annual farm-level data from the U.S. Department of Agriculture's ARMS survey, 1996-2006. We include all 10 ERS production regions and all farms. Alternatively, we estimate the model excluding farms with gross value of sales less than $100,000. We hypothesize that agricultural specialization directly affects the asset efficiency and gross margin of the farm. Specifically, specialization would tend to decrease asset efficiency while increasing the gross margin. On the other hand, vertical integration may affect the gross margin and solvency directly. The effect on solvency would result from the integrator's use of credit as an incentive. Specifically, livestock operations may tend to have greater asset efficiency than crop farms. Our results are preliminary and, as expected, vary across farm production regions and across farm types (crop versus livestock). However we do find evidence that specialization and vertical integration are key factors driving farm profitability in the U.S.

2. The Empirical Model

Following the DuPont formulation in Moss, Mishra, and Erickson, we begin with the expansion of the rate of return on equity:

$$\frac{R}{E} = \frac{S-C}{S}\frac{S}{A}\frac{A}{E} \quad (1)$$

where R is the rate of return on farm business equity, S is the level of agricultural sales, C is the cost of production, A is the level of agricultural assets, and E is the level of agricultural equity. The DuPont expansion in equation (1) shows how the rate of return to equity can be related to the gross margin on agricultural sales (S-C)/S, the asset efficiency measured by the asset turnover ratio (S/A) and the firm's solvency (A/E). Following Moss, Mishra and Erickson, we note that this "traditional" DuPont equation is linear in the logs:

$$\ln\left(\frac{R}{E}\right) = \ln\left(\frac{S-C}{S}\right) + \ln\left(\frac{S}{A}\right) + \ln\left(\frac{A}{E}\right) \quad (2)$$

Following this formulation, we posit a system of four equations in log space

$$
\begin{aligned}
\ln\left(\frac{R}{E}\right) &= \alpha_{10} + \alpha_{11}J + \alpha_{12}a + \alpha_{13}x + \varepsilon_1 \\
\ln\left(\frac{S-C}{S}\right) &= \alpha_{20} + \alpha_{21}J + \alpha_{22}a + \alpha_{23}I + \alpha_{24}y + \varepsilon_2 \\
\ln\left(\frac{S}{A}\right) &= \alpha_{30} + \alpha_{31}J + \alpha_{32}a + \alpha_{32}I + \alpha_{34}z + \varepsilon_3 \\
\ln\left(\frac{A}{E}\right) &= \alpha_{40} + \alpha_{41}J + \alpha_{42}a + \alpha_{43}I + \alpha_{44}z + \varepsilon_4
\end{aligned} \qquad (3)
$$

where *J i*s the entropy measure of diversification to be discussed below, *a* is the acres operated by the firm used to capture scale effect, *I* is a measure of vertical integration, x, y, and z are vectors of variables used to remove other effects from the system and ε_i are error terms. The first of the four equations in the log of the DuPont system can be dropped due to summing up conditions similar to a demand system.

The entropy index is a measure of concentration proposed by Shannon and Weaver. We use an alternative measure of entropy, the Theil definition of entropy (TMI). If we define s_i as the share of farm's revenues that are attributable to activity i, the entropy index can be defined as

$$J = -\sum_i s_i \ln(s_i) \quad (4)$$

Note that s ln(s)=0 as s approaches 0. This measure of concentration reaches a minimum at 0 as the shares approach zero for all enterprises except one. This would represent a completely specialized firm producing a single output. At the other extreme, the entropy index reaches a maximum of ln(N) where N is the number of possible crops and livestock activities.

3. Data

The rich and extensive data in the USDA-ARMS survey make our analysis possible. The ARMS survey is an annual survey covering farms in the 48 contiguous States. This survey is designed to incorporate information from both a list of farmers producing selected commodities and a random sample of farmers based on area. Since stratified sampling is used, inferences regarding the means of variables for states and regions are conducted using weighted observations. We apply the USDA's in-house jackknifing procedure that it believes is most appropriate when analyzing ARMS data (Dubman, Kott; Cohen, and Jones).

We link nine annual ARMS surveys to form a pooled time-series cross-section, assuming that the survey design for each year is comparable. Hence, we are able to use the annual ARMS survey data to examine structural changes over time. Incorporating the survey weights, and following the jackknifing procedure described in Kott, assures that regression results are suitable for inference to the population in each of the regions analyzed.

4. Estimation of the DuPont System

The system of DuPont equations in Section 2 was estimated by OLS using repeated cross-sections regression (RCS) using annual farm-level data from the U.S. Department of Agriculture's Agricultural Resource Management Survey (ARMS) data, 1996-2006, with (one-way) fixed effects: year. We estimate three of the four DuPont equations for the 10 USDA-ERS production regions for all farms (family and non-family farms). The first equation of the four,

$$\frac{R}{E} = \frac{S-C}{S}\frac{S}{A}\frac{A}{E} \qquad (1)$$

can be dropped due to summing up conditions similar to a demand system.

Farm-level estimates of the *R* (the rate of return on farm business equity), S (the level of agricultural sales), *C* (the cost of production), *A* (the level of agricultural assets), *E* (the level of agricultural equity). The index of vertical integration (*I*) is estimated as the proportion of total value of production from contracts.

Following the empirical model and DuPont system of equations in Section 2, we formulate four hypotheses about the factors driving the rate of return on equity:

H1: *Agricultural specialization (J)*directly affects the asset efficiency (SA) and gross margin (S-C/S) of the farm. Specifically, specialization would tend to decrease asset efficiency while increasing the gross margin.

H2: *Vertical Integration, I,* may affect the gross margin and solvency directly (A/E), and thus too the rate of return (R/E).

H3: *Acres operated, a,* may lead to scale economies for larger farms.

H4: *Type farm* (crop or livestock) may also affect rates of return. That is, the general type of agricultural enterprise integrated may also have implications for asset efficiency. Specifically, livestock operations may tend to have greater asset efficiency than crops.

Our review of the literature on the *firm,* including recent transaction cost theory, reveals a set of complex links between agricultural specialization, vertical integration, scale, and farm type. To help us understand the key factors *driving* the profitability of the farm. We estimate the following DuPont model using ARMS farm-level RCS data, 1996-2006. The econometric models presented here are:

$$Model1: \ln\left(\frac{A}{E}\right) = \alpha_{10} + \alpha_{11}J + \alpha_{12}a + \alpha_{13}x + \varepsilon_1$$
$$Model2: \ln\left(\frac{S-C}{S}\right) = \alpha_{20} + \alpha_{21}J + \alpha_{22}a + \alpha_{23}I + \alpha_{24}y + \varepsilon_2$$
$$Model3: \ln\left(\frac{S}{A}\right) = \alpha_{30} + \alpha_{31}J + \alpha_{32}a + \alpha_{32}I + \alpha_{34}z + \varepsilon_3$$

with a "Year" dummy for the one-way fixed effects model.

Our specific parameterization of the DuPont equations is as follows:

Model 1- (Solvency): Asset To Equity Ratio

ln(A/E) = f(*Acres Operated*, *Theil Entropy*, *Index Of Vertical Integration*, *Farm Size*, and *Farm Size* interacted with AcresOperated)

Model 2- (Profitability): Net Profit Margin:

ln(S-C/S) = f(*Acres Operated*, *Theil Entropy*, *Farm Type*, *Farm Size*, and *Farm Size* interacted with *AcresOperated*)

Model3 – (Efficiency): Asset Turnover:

ln(S/A) = f(*AcresOperated*, *TheilEntropy*, *FarmType*, *IndexOfVerticalIntegration*, *GetGovernmentPayments*, *GetOffFarmIncome*, *FarmSize*, and *FarmSize* interacted with *AcresOperated*).

4. Results

Before running the OLS regressions on the three DuPont equations, we split the sample into two groups: (1) All farms, Small, Medium, and Large Farms, and (2) Medium and Large Farms only (we excluded farms whose gross value of sales is less than $100,000).

Statistical examination of the DuPont expansion indicates that the differences in the distribution for each ratio in a given time period are statistically significant. However, differences in the distribution of the rate of return on all factors across time are significant and primarily attributable to differences in the profit margin and solvency over time.

Specifically, statistical differences in the profit margins are observed in seven of the ten production regions. Similar differences are observed for the asset to equity ratio. The results of this study suggest that cross sectional variation in the rate of return to assets is primarily determined by the asset turnover ratio and the gross margin.

We ran OLS regressions with one-way fixed effects (year), repeated cross sections, 1996-2006. We parameterized the three regressions based on our literature review (e.g., Collins(1985), Coase (1937), Barnard and Boehlje(2004), and Anderline and Felli(2006). Our results must be viewed as preliminary for several reasons. First, we need to more thoroughly examine these initial results, checking for omitted variables, measurement error, etc. Second, we need to consider alternative parameterizations of the DuPont model.

H1: *Agricultural specialization* (J) would tend to decrease asset efficiency while increasing the gross margin. To represent *agricultural specialization*, we used the Theil entropy measure (TMI). The TMI measures how concentrated total income from production is for the farm and the greater the diversity of crops and livestock produced, the greater the TMI. We included the TMI in all three equations and found evidence that agricultural specialization decreases asset efficiency (negative signs on the *IndexVertIntegration* coefficient and statistically significant) in the *AssetTurnover equation* for farms in the Northeast, Lake States, Corn Belt , Appalachia, Southeast and Delta. We found no evidence that agricultural specialization increases the gross margin since in the *NetProfitMargin equation*, the TMI was not significant in any region.

H2: *Vertical integration*, *I*, may affect the gross margin and solvency directly, and thus too the rate of return.

To represent *vertical integration*, we used the farm's share of value of production from contracting divided by the total value of production (Appendix Table A). We found that vertical integration may increase solvency (raise the A/E ratio), but only in the Southeast. We did not test the effect of *vertical integration* on the gross margin, but will do so in future research.

H3 *Acres operated*, a, may lead to scale economies for larger farms.

Acres operated is reported in the USDA-ARMS survey. We included *acres operated* in each of the three equations. *Acres operated* was statistically significant in the AssetTurnover equation for the Corn Belt, Northern Plains, Appalachia, Southeast, Delta, Southern Plains, Mountain States, and Pacific. This suggests that acres operated may lead to scale economies through improving financial liquidity. Acres operated was statistically significant in the NetProfitMargin equation for the Northeast, Lake States, Corn Belt, Northern Plains, Delta, Southern Plains, and Mountain States. This also suggests that *acres operated* may lead to scale economies in these regions.

H4: Type farm (crop or livestock) may also affect rates of return. Specifically, the general type of agricultural enterprise integrated may also have implications for asset efficiency. Specifically, livestock operations may tend to have greater asset efficiency than crops.

We found that FarmType affected rates of return, both through the *NetProfitMargin* and through the *AssetsToEquity ratio.* FarmType was statistically significant in the Corn Belt, Northern Plains, Appalachia, Southeast, Delta, Southern Plains, and Mountain States. FarmType also affected profitability by affecting solvency (*AssetsToEquity*), but only in the Mountain States.

5. Conclusion

In order to examine the significance of specialization and vertical integration on domestic agriculture, we used a financial approach based on the DuPont expansion. In the current study, we hypothesize that agricultural specialization directly affects the asset efficiency and gross margin of the farm. Specifically, specialization would tend to decrease asset efficiency while increasing the gross margin. On the other hand, vertical integration may affect the gross margin and solvency directly. The effect on solvency would result from the integrator's use of credit as an incentive. However, the general type of agricultural enterprise integrated may also affect asset efficiency. Specifically, livestock operations may tend to have greater asset efficiency than crops. We estimated a system of equations in log space using annual farm-level data from the USDA's ARMS data, 1996-2006. We included all production regions in the contiguous 48 states, and all farms. We found evidence that specialization and vertical integration are among the key factors driving farm profitability in the U.S.

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Table 1. Regression results for investment share equations by region (one-way fixed effects): Small, Medium, and Large Farms										
DuPont equation 1: lnAssetTurnoverRatio = f(Acres, TheilEntropy, Farm type, FarmSize, FE: year)										
	Northeast		*Lake States*		*Corn Belt*		*Northern Plains*		*Appalachia*	
Variable	Estimate	t-value	Estimate	t-value	Estimate	t-value	Estimate	t-value	Estimate	t-value
LnAssetTurnoverRatio										
Acres	-0.0001	-1.04	-0.0001***	-3.59	-0.0001***	-6.39	-0.0001***	-11.40	0.0001**	2.25
TheilEntropy	-.1020***	-2.59	-0.0041	-0.16	0.0671***	3.04	0.1163***	5.14	0.3721***	12.31
Farm type	0.1272***	7.06	0.1776***	15.17	0.1561***	15.69	0.1188***	9.77	0.0873***	6.84
Index VertIntegration	0.0166	0.64	0.1504***	5.98	0.0135	1.00	0.1879***	7.17	-0.0119	-0.62
GetGovtPayments	0.1177***	4.01	0.0660***	3.06	0.2303***	13.53	0.2040***	7.82	0.2485***	12.01
GetOffFarmIncome	-0.2812***	-7.25	-0.1764***	-6.09	-0.1192***	-5.21	-0.1299***	-4.45	-0.3042***	-10.29
SmallFarm	-1.1151***	-15.29	-0.8127***	-16.86	-0.7827***	-19.94	-0.7758***	-16.91	-1.0650***	-19.55
MediumFarm	0.0017	0.03	-0.1106***	-3.05	-0.0140	-0.42	-0.1943***	-5.68	0.1643***	3.34
Acres*SmallFarm	0.0001	0.01	0.0002***	3.08	0.0001***	3.38	0.0001***	4.03	-0.0003***	-5.96
Acres*MediumFarm	-0.0006***	-6.06	-0.0002***	-5.06	-0.0004***	-10.64	-0.0001***	-5.50	-0.0005***	-9.16
Fixed effects:										
Year	***		***		***		***		***	
DuPont equation 2: lnNetProfitMargin = f(Acres, TheilEntropy, Farm type, FarmSize, FE: year)										
lnNetProfitMargin										
Acres	-0.0005***	-5.47	-0.0003***	-5.78	-0.0001***	-3.81	-0.0001***	-3.57	-0.0001***	-2.66
TheilEntropy	-0.2624**	-1.66	0.0449	0.39	-0.0896	-0.97	0.2850***	2.84	-0.2491**	-2.04
Farm type	0.1740***	2.37	0.1506***	2.70	0.2051***	4.71	0.3075***	5.44	0.0602	1.11
SmallFarm	-0.9758***	-3.31	-0.6202***	-2.72	-0.1057	-0.62	0.2412	1.13	-0.5063***	-2.22
MediumFarm	0.7683***	3.21	1.1630***	6.75	0.9076***	6.28	0.5175***	3.25	0.7368***	3.53
Acres*SmallFarm	-0.0015***	-4.94	-0.0013***	-5.13	-0.0008***	-6.07	-0.0002***	3.59	-0.0014***	-7.69
Acres*MediumFarm	-0.0025***	-6.05	-0.0021***	-11.02	-0.0001***	-9.63	-0.0002***	-4.78	-0.0018***	-7.19
Fixed effects:										
Year	***		***		***		***		***	
DuPont equation 3: lnAssetsToEquity = f(Acres, TheilEntropy, Farm type, FarmSize, Acres*FarmSize, FE: year)										
lnAssetsToEquity										
Acres	0.0001***	3.89	-0.0001***	-4.21	0.0001	0.06	-0.0001	-0.32	-0.0001	-0.31
TheilEntropy	0.0800**	1.91	0.1043***	3.45	0.1209***	4.90	0.1465***	5.19	0.0151	0.46
Farm type	0.0195	1.01	0.0091	0.62	0.0139	1.20	0.0043	0.27	0.0266**	1.85
IndexVertIntegration	0.0514**	1.87	0.0282	0.89	0.0229*	1.45	0.0175	0.51	-0.0057	-0.26
SmallFarm	0.0751	0.96	-0.1098**	-1.82	0.0096	0.21	-0.0645	-1.08	0.0417	0.68
MediumFarm	0.1272**	2.01	-0.0809**	-1.78	-0.0187	-0.49	-0.0534	-1.19	0.0096	0.17
Acres*SmallFarm	-0.0002**	-1.80	0.0001	0.99	0.00001	0.86	-0.0001	-0.62	0.00001	0.96
Acres*MediumFarm	-0.0002**	-1.93	0.0001**	2.07	0.00001	1.07	0.0001***	1.78	-0.0001	-0.27
Fixed effects:										
Year	*		NS		**		NS		NS	
*** = statistical significance at the 0.01 confidence level; ** = .05 confidence level; * = .10 confidence level; NS = not statistically significant.										
Source: 1996-2006 USDA-ARMS survey.										

Table 2. Regression results for investment share equations by region (one-way fixed effects):Medium and Large farms										
DuPont equation 1: lnAssetTurnoverRatio = f(Acres, TheilEntropy, Farm type, FarmSize, FE: year)										
	Southeast		*Delta*		*Southern Plains*		*Mountain States*		*Pacific*	
Variable	Estimate	t-value	Estimate	t-value	Estimate	t-value	Estimate	t-value	Estimate	t-value
lnAssetTurnoverRatio										
Acres	-0.0001***	-4.22	0.0001***	14.13	-0.0001***	-7.02	-0.0001***	22.01	-0.0001***	12.10
TheilEntropy	0.4300***	12.38	0.3165***	7.26	0.2810***	8.72	0.1820***	4.91	-0.1552***	-4.16
Farm type	0.1224***	8.61	0.0804***	4.61	0.1409***	9.61	0.2115***	10.76	0.2157***	13.47
IndexVertIntegration	-0.0001	-0.16	0.0011	0.94	-0.0003	-0.47	0.4145***	10.97	0.0630***	3.99
GetGovtPayments	0.1976***	8.41	0.6571***	24.58	0.4968***	20.53	0.2528***	8.25	0.2613***	10.38
GetOffFarmIncome	-0.3595***	-11.95	-0.2503***	-8.45	-0.2723***	-7.48	-0.1519***	-3.92	-0.2203***	-7.32
SmallFarm	-1.1663***	-19.68	-1.0189***	-14.07	-1.1075***	-18.89	-0.6559***	-9.04	-1.0509***	-16.45
MediumFarm	-0.0457	-0.99	0.0838*	1.38	-0.3004***	-6.74	-0.2427***	-4.85	-0.3183***	-7.07
Acres*SmallFarm	-0.0001***	-4.58	-0.0003***	-8.14	-0.0001	-0.71	0.0001	1.21	-0.0001	-0.63
Acres*MediumFarm	-0.0001***	-5.19	-0.0004***	-7.93	-0.0001***	-5.02	-0.0001***	-5.93	-0.0001***	-3.62
Fixed effects:										
Year	***		***		***		***		***	
DuPont equation 2: lnNetProfitMargin = f(Acres, TheilEntropy, Farm type, FarmSize, FE: year)										
lnNetProfitMargin										
Acres	-0.0001	-0.74	-0.0002***	-5.48	-0.0002***	-3.13	-0.0001***	-4.04	-0.0001	-1.12
TheilEntropy	-0.8947***	-7.48	-0.0970	-0.60	0.2318**	1.85	-0.2035*	-1.46	-0.5354***	-4.16
Farm type	-0.0169	-0.31	0.2143***	3.18	0.1423***	2.38	0.3358***	4.33	0.0574	0.98
SmallFarm	-1.1998***	-5.33	-0.7895***	-2.84	-1.3485***	-5.64	0.08034	0.28	-0.7953***	-3.41
MediumFarm	-0.5116***	-2.91	0.3753*	1.60	-0.3103**	-1.71	0.4415**	2.23	-0.2499*	-1.51
Acres*SmallFarm	-0.0002***	-4.44	-0.0007***	-4.85	-0.0001*	-1.53	-0.0001**	-2.30	-0.0002***	-4.51
Acres*MediumFarm	-0.0001*	-1.40	-0.0012***	-6.12	-0.0001***	-3.46	-0.0001**	-2.05	-0.0001**	-2.13
Fixed effects:										
Year	***		***		***		***		***	
DuPont equation 3: lnAssetsToEquity = f(Acres, TheilEntropy, Farm type, FarmSize, Acres*FarmSize, FE: year)										
lnAssetsToEquity										
Acres	-0.0001	-0.51	-0.0001***	-6.84	0.0001	0.98	0.0001***	26.67	0.00001	0.32
TheilEntropy	0.0108	0.37	-0.1409**	-2.05	0.1004***	2.66	0.0997***	2.48	0.0792**	1.71
Farm type	0.0319***	2.38	0.0181	0.64	0.0338**	1.87	0.0314*	1.39	0.0023	0.11
IndexVertIntegration	0.0001	0.10	0.0003	0.15	-0.0001	-0.02	-0.0040	-0.09	0.0269*	1.29
SmallFarm	0.0818*	1.47	0.0148	0.13	0.1168*	1.62	0.1288*	1.55	0.1695**	2.02
MediumFarm	0.0537	1.24	-0.0987	-1.00	0.0474	0.86	0.0896	1.57	0.1618	2.73
Acres*SmallFarm	-0.0001	-0.19	0.0001	0.72	-0.0001	-0.59	-0.0001	-0.61	0.00001	-0.26
Acres*MediumFarm	0.0001	0.22	0.0001	1.38	0.00001	0.10	0.00001	0.79	0.00001	0.20
Fixed effects:										
Year	NS		NS		NS		NS		NS	
*** = statistical significance at the 0.01 confidence level; ** = .05 confidence level; * = .10 confidence level; NS = not statistically significant.										
Source: 1996-2006 USDA-ARMS survey.										

Table 3. Regression results for investment share equations by region (one-way fixed effects): Medium and Large Farms										
DuPont equation 1: lnAssetTurnoverRatio = f(Acres, TheilEntropy, Farm type, FarmSize, FE: year)										
	Northeast		*Lake States*		*Corn Belt*		*Northern Plains*		*Appalachia*	
Variable	Estimate	t-value	Estimate	t-value	Estimate	t-value	Estimate	t-value	Estimate	t-value
lnAssetTurnoverRatio										
Acres	-0.0001	-0.13	-0.0001***	-2.7	-0.0001***	-7.30	-0.0001***	-17.77	0.0001***	4.36
TheilEntropy	-0.3174***	-7.33	-0.1673***	-6.29	-0.1624***	-6.10	0.0330*	1.36	0.1891***	5.36
Farm type	0.3545***	10.62	0.397***	19.22	0.3785***	20.32	0.4340***	19.09	0.1685***	6.64
IndexVertIntegration	-0.2153***	-9.62	-0.0326	-1.43	-0.1023***	-6.53	0.0947***	4.14	-0.2027***	-11.69
GetGovtPayments	-0.0301	-1.01	-0.256***	-9.82	0.0376*	1.59	-0.1109***	-3.04	0.1205***	4.86
GetOffFarmIncome	-0.135***	-3.95	-0.096***	-3.89	-0.0505***	-2.27	-0.0474**	-1.78	-0.1956***	-7.09
MediumFarm	0.3468***	5.30	0.2129***	5.58	0.3053***	8.43	0.2472***	6.23	0.2767***	5.08
Acres*MediumFarm	-0.0005***	-6.53	-0.0002***	-5.37	-0.0003***	-11.51	-0.0001***	-7.02	-0.0005***	-11.05
Fixed effects:										
Year	***		***		***		***		***	
DuPont equation 2: lnNetProfitMargin = f(Acres, TheilEntropy, Farm type, FarmSize, FE: year)										
lnNetProfitMargin										
Acres	-.0005***	-5.88	-.0039***	-5.99	-.0002***	-4.71	-.00004***	-3.90	-.00013***	-2.79
TheilEntropy	-.1111	-.55	.1086	.75	.04787	.39	.2058*	1.62	-.3165**	-2.04
Farm type	.2527*	1.60	.0365	.31	.3305***	3.75	.4327***	3.47	.3525***	2.94
MediumFarm	.8985***	2.91	.972***	4.46	1.0594***	6.12	.6852***	3.13	1.22***	4.73
Acres*MediumFarm	-0.0025***	-6.80	-0.002***	-12.19	-0.0014***	-10.28	-0.0002***	-5.06	-0.0017***	-7.80
Fixed effects:										
Year	***		***		***		***		***	
DuPont equation 3: lnAssetsToEquity = f(Acres, TheilEntropy, Farm type, FarmSize, Acres*FarmSize, FE: year)										
lnAssetsToEquity										
Acres	0.00001***	3.55	-0.001***	-3.68	-0.00001	-0.14	0.00001	0.04	-0.00001	-0.36
TheilEntropy	0.09001*	1.38	0.1725***	3.60	0.2107***	5.29	0.1904***	4.90	0.04606	0.83
Farm type	-0.06666*	-1.31	-0.01985	-0.51	-0.00472	-0.16	-0.04602	-1.20	0.02893	0.68
IndexVertIntegration	0.04898*	1.45	0.03148	0.73	0.04841**	1.98	0.02716	0.70	-0.0032	-0.11
MediumFarm	-0.01083	-0.11	-0.1261**	-1.75	-0.04942	-0.88	-0.1255**	-1.87	0.000828	0.09
Acres*MediumFarm	-0.00022*	-1.84	0.00001**	1.72	0.00001	0.88	0.00001**	1.75	-0.00001	-0.19
Fixed effects:										
Year	NS		NS		*		*		NS	
*** = statistical significance at the 0.01 confidence level; ** = .05 confidence level; * = .10 confidence level; NS = not statistically significant.										
Source: 1996-2006 USDA-ARMS survey.										

Table 4. Regression results for investment share equations by region (one-way fixed effects): Medium and Large Farms										
DuPont equation 1: lnAssetTurnoverRatio = f(Acres, TheilEntropy, Farm type, FarmSize, FE: year)										
	Southeast		*Delta*		*Southern Plains*		*Mountain States*		*Pacific*	
Variable	Estimate	t-value	Estimate	t-value	Estimate	t-value	Estimate	t-value	Estimate	t-value
lnAssetTurnoverRatio										
Acres	-0.0001***	-7.32	0.0001***	15.6	-0.0001	1.00	-0.00001	1.00	-0.0001***	-13.13
TheilEntropy	0.2201***	5.85	0.2451***	5.22	0.1194***	3.26	0.1655***	3.94	-0.0881**	-2.13
Farm type	0.3286***	11.82	0.1320***	4.28	0.3189***	10.03	0.7691***	19.87	0.5016***	16.15
IndexVertIntegration	-0.7184***	-29.47	0.0007	0.74	-0.0004	-0.77	0.2935***	7.47	-0.02181*	-1.40
GetGovtPayments	0.1406***	5.38	0.6096***	18.97	0.4144***	12.61	0.03128	0.79	0.1068***	3.84
GetOffFarmIncome	-0.2546***	-9.23	-0.2183***	-7.61	-0.1816***	-5.21	-0.02762	-0.72	-0.1151***	-3.77
MediumFarm	0.1380***	2.44	0.1662***	2.43	0.0046	0.08	0.6123***	8.87	0.1418**	2.30
Acres*MediumFarm	-0.0001***	-7.25	-0.0004***	-8.74	-0.0003***	-6.20	-0.0002***	-7.07	-0.003***	-3.73
Fixed effects:										
Year	***		***		***		***		***	
DuPont equation 2: lnNetProfitMargin = f(Acres, TheilEntropy, Farm type, FarmSize, FE: year)										
lnNetProfitMargin										
Acres	-.00002*	-1.54	-.00024***	-6.83	-.00002***	-3.55	-.00001***	-4.23	-.00001*	-1.33
TheilEntropy	-.3821***	-2.76	-.1073	-0.59	.3352**	2.17	-.1788	-1.06	-.5384***	-3.72
Farm type	.4621***	3.85	.7030***	5.71	.4036***	2.82	.5949***	3.61	.02029	0.17
MediumFarm	.2581	1.05	1.0985***	3.98	.1013	.38	.8331***	2.80	-.3045*	-1.30
Acres*MediumFarm	-0.0001*	-1.49	-0.0011***	-6.38	-0.0001***	-3.86	-0.0001**	-2.10	-0.0001***	-2.35
Fixed effects:										
Year	***		***		***		***		***	
DuPont equation 3: lnAssetsToEquity = f(Acres, TheilEntropy, Farm type, FarmSize, Acres*FarmSize, FE: year)										
lnAssetsToEquity										
Acres	-0.00001	-0.19	-0.00001***	-5.61	0.00001	0.93	0.00001	1.00	0.00001	0.20
TheilEntropy	0.0774*	1.63	-0.1463*	-1.55	0.1038**	1.68	0.1316**	2.26	0.1175	1.81
Farm type	0.04819	1.18	0.02908	0.45	0.04261	0.74	-0.1906***	-3.32	-0.09056**	-1.71
IndexVertIntegration	0.1399***	3.91	0.00004	0.17	-0.00003	-0.03	0.05298	0.91	0.03025	1.14
MediumFarm	0.1189*	1.43	-0.0809	-0.56	0.07217	0.67	-0.246***	-2.39	0.006426	0.06
Acres*MediumFarm	0.00001	0.29	0.00001	1.20	0.00001	0.11	0.000001	0.74	0.000001	0.16
Fixed effects:										
Year	NS		NS		NS		NS		NS	
*** = statistical significance at the 0.01 confidence level; ** = .05 confidence level; * = .10 confidence level; NS = not statistically significant.										
Source: 1996-2006 USDA-ARMS survey.										

Appendix Table A. Variable description and source			
Variable	Description	Calculated using ARMS variables as:	Source
NetProfitMargin	Net profit margin	((INFI-V22A-V22E+EFINT)/IGFI*100)	ARMS
AssetTurnover	Asset turnover ratio	(IGFI)/ATOT	ARMS
AssetsToEquity	Asset to equity ratio	ATOT/NETW	ARMS
AcresOperated	Acres operated	Not calculated.	ARMS
TheilEntropy	Theil measure of entropy	Described in text.	Calculated using ARMS data.
FarmSize (small, medium, large)		Small: gross value of sales < $100,000; Medium: $100,000 <= gross value of sales < $250,000; Large: $250,000 <= gross value of sales < $500,000.	ARMS
Acres_SmallFarm	Interaction variable	AcresOperated * SmallFarm	ARMS
Acres_MediumFarm	Interaction variable	AcresOperated*MediumFarm	ARMS
IndexVerticalIntegration	Index of farm vertical integration	Value of production under contract/Total value of production	ARMS
GetGovtPayments	Dummy variable 1=yes 0 = no	IGOVT	ARMS
GetOffFarmIncome	Dummy variable 1=yes 0 = no	TOTOFI	ARMS
Year	Year of ARMS survey	Year	ARMS