Productivity Growth, Technological Progress, and Technical Efficiency In the Heartland and Southern Cotton States: 1996-1999

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by

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Abstract

Given recent concerns expressed about the structural transformation of agriculture and the health of the family farm this study provides a measure of the economic health of small and large farms at the state level. We use nonparametric frontier methods to measure and explain changes in the efficiency, productivity, and technological change of U.S. farms, employing USDA's annual 1996 to 1999 surveys of farms. Our results for the corn and cotton states analyzed identify particularly weak economic performance of small farms in Iowa, Louisiana, Oklahoma, and Wisconsin and of large farms in Missouri, Oklahoma, and South Carolina. Our results also indicate strong performance of small farms in several states. Thus, these results give policy makers a more detailed and up to date view of the overall economic health of the agricultural sector in the states analyzed than has previously been possible with aggregate state level analyses.

Key words: total factor productivity, nonparametric, efficiency, technological change, quality-adjusted.

Introduction

This study provides a quantitative evaluation of productivity growth, technological progress, and technical efficiency of farm-level operations within the Heartland, the Prairie Gateway, the Mississippi Portal, and the Southern Seaboard. These regions, recently defined by USDA to allow a sharper focus on specialized crop and livestock activity by resource region, provide a range of urban and rural influences involving dramatic changes in farm structure in the last decade (Hoppe et. al.). The Economic Research Service (ERS) has developed a farm typology (Hoppe, Perry, and Banker) that groups farms based on the sales, occupation of operator, farm assets, and total household income (figure 1). The contribution of this study is to measure productivity measures employing USDA's annual surveys of farms for 1996 to 1999. The problem of linking annual cross-section data intertemporaly is addressed by constructing a pseudo panel data set.

Within the last decade dramatic changes in farm size, livestock concentration, and urbanization pressures on farmland have arguably changed forever the structure of traditional agriculture so familiar to generations of farmers. The trend toward larger farms has been a policy concern at least since the 1970's and continues to be seen as a threat to the small family farm. (National Commission on Small Farms). Trends toward larger farms and livestock concentration or corporate industrialization and contracting out of hog production, unless offset by off-farm income opportunities raise questions about the long-term survival of remaining small independent operations, facing increasingly different urban pressures and economic growth patterns, county by county. Further, as farm structure changes via urbanization, questions arise as to what the combination of farm and household activity (and associate government policies) means for the economic performance of the farm household.

Between 1980-97 average farm size in the Heartland rose by 23 percent to 297 acres, implying significant size economies. In contrast, the average farm size in the Southern Seaboard and Mississippi Portal states grew by only 7 and 5 percent, respectively, and actually decreased in the Prairie Gateway due in part to an increase in ranchettes[1] (Table 1). As shown in table 1, the trend toward increased livestock concentration into a small number of economic units, particularly in the hog and beef sectors, is even more impressive (Iowa State University, MacDonald and Ollinger). The heartland data masks extraordinarily rapid concentration of hog production in only a few Iowa counties, for example in

1 The term ranchette is used in cotton states to characterize small farms of 5 to 10 acres, usually operated by individuals whose full time

north-central Iowa. Finally, off-farm income and business opportunities have become increasingly important in many agricultural areas. One gauge of such trends is the relative level and percent change in population accessibility (size of and distance from urban areas). As shown in Nehring et. al., levels are highest in the eastern Heartland and Southern Seaboard, but percent change in population accessibility between 1970 and 1990 was most rapid in the Prairie Gateway and Southern Seaboard. Recent census data indicates that population growth has exploded in the southern cotton states, implying relatively strong growth in off-farm opportunities (table 2). Kumbhakar et. al. (for dairy farms), Sharma et. al. (for hog farms), Heshmati et. al. (for grain farms) provides recent evidence from frontier models, that large farms are more efficient or productive than small farms. Peterson has provided evidence that small farms may be as efficient as large farms if farm employment and the value of the farm residence are taken into account.

Quality adjustment issues have recently gained prominence in the productivity and frontier literature. The productivity literature implies that excluding quality-adjustments in disaggregated input measures--that is treating an hour worked by a highly educated skilled worker as equivalent to an hour worked by a less educated, unskilled worker--is tantamount to assuming away input substitution possibilities, and results in a biased measure of productivity as first noted by Jorgenson and Gollop[2]. Analogously, omission of quality-adjustments in the frontier production function leads to biased measures of output elasticities and technical efficiency. Alvarez and Gonzalez (1999) compare Spanish dairy farms and find that conclusions derived from analyses incorporating quality adjustments for a number of inputs are different from those not including quality adjustments. This result suggests that some of the conclusions obtained in studies of technical efficiency may depend heavily on the information about input quality. Historically, frontier procedures have handled the input quality problem with a two-stage approach where technical efficiency is estimated in the first stage, and factors affecting technical efficiency are analyzed in a second stage (Kalirajan). As Alvarez and Gonzalez note, differences in TE can be attributed to unmeasured inputs, differences in input quality, and different technologies, and management can be one of the

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job is located in an urban location.

2 The quality-adjustment issue was more fully addressed in the agricultural productivity literature in Ball et. al. (1997), where productivity measures incorporated quality adjustments for labor, fertilizer and pesticides, and in Ball et. al. USDA (2000) and Ball et. al. (JPA 2000) where quality-adjusted land measures were added to U.S. and international productivity accounts.

unmeasured inputs. Assuming a common technology, inclusion of input quality adjustments in the production function specification allows us to more properly evaluate the remaining technical efficiency factors as relating to management.

Panel Data on U.S. Agriculture

The U.S. farm level data, used to construct panel data for 1996-1999, have been obtained from the 1996, 1997, 1998 and 1999 Agricultural Resources Management Study (ARMS) Phase III survey. The ARMS, Phase III is an annual survey covering U.S. farms in the 48 contiguous states conducted by the National Agricultural Statistics Service, USDA, in cooperation with the Economic Research Service.

Two regions were selected for analysis. The first region, which we refer to as the Corn Belt consists of the following states: Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri, Nebraska, Ohio, South Dakota, and Wisconsin. The second region consists of the states of Alabama, Arkansas, Georgia, Louisiana, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, and Virginia. The two regions were selected because they represent major soil types, cropping patterns, pedo-climatic regimes, off-farm employment opportunities, and urbanization trends in major corn/soybean and cotton producing areas and provide adequate observations for analysis. The USDA data permit other regional analyses of other major producing areas such as the Northern Plains, or Southwest, but such analyses are beyond the scope of this study.

In empirical studies of production, the temporal pattern of a farm's production behavior is often of considerable interest. In the absence of genuine panel data, repeated cross-sections of data across the farm typologies described earlier are used to construct pseudo panel data (see Deaton, Heshmati et. al., Verbeek et.al.) The pseudo panels are created by grouping the individual observations into a number of homogeneous cohorts, demarcated on the basis of their common observable time-invariant characteristics, such as geographic location, quality of land, size of land, scope of agricultural activities relative to off-farm activities, etc. The subsequent economic analysis uses, in general, the cohort means rather than the individual farm-level observations.

The recent development at ERS of a farm typology, described in detail in Figure 1, allows us to assign farm-level data to cohorts by typology group, and sub typology group, by state, by year for the two regions analyzed. The data in groups 1 through 3 (limited resource, retirement, and residential) is relatively limited compared to the traditional farm data in groups 4 through 7, particularly cohorts 1 and 2. Hence, groups 1 through 3 were grouped into two cohorts by level of agricultural sales in both regions. For groups 4 through 8 the construction of cohorts differed between the two regions because of generally sparser data in the cotton states. compared to the Corn Belt. In the cotton states each of the groups 4,5, 6, were grouped into two cohorts each and typologies 7 and 8 were combined into two cohorts. In the Corn Belt the data in each of typologies 4, 5, and 6 was used to form three cohorts, while data in groups 7 and 8 were grouped into two cohorts, as in the cotton states. Hence, our panel data set consists of 13 cohorts by state in the Corn Belt and 10 cohorts by state in the cotton states, measured as the weighted mean values of the variables to be analyzed. The total number of annual observations involved in our analyses are 130 for the Corn Belt states of (IL, IN, IA, IMI, MN, MO, NE, OH, SD, and WI) and 110 observations in the cotton states of (AL, AR, GA, LA, MS, NC, OK, SC, TN, TX, and VA) for both 1996-1999. The numbers of farms involved in the Corn Belt is 1857 in 1996, 2440 in 1997, 2158 in 1998 and 2916 in 1999. The numbers of cotton state farms is 2015 in 1996, 2121 in 1997, 2164 in 1998 and 2609 in 1999.

The Nonparametric Approach

Following Färe et al (1994), the Malmquist (output-orientated) Total Factor Productivity (TFP) change index between period s (the base period) and period t is given by

$$m_o(y_s, x_s, y_t, x_t) = [\, d^s_o(y_t, x_t) / d^s_o(y_s, x_s) \times d^t_o(y_t, x_t) / d^t_o(y_s, x_s) \,]^{1/2}$$

where the notation $d^s_o(y_t, x_t)$ represents the distance from the period t observation to the period s technology. A value of m_o greater than one will indicate positive TFP growth from period s to period t while a value less than one indicates a TFP decline. We can compute TFP and characterize it as due to improvements in technical change (or innovation), technical efficiency change (improvements in efficiency), pure technical efficiency (technical efficiency under variable returns to scale), and scale efficiency.

Data and Results

We calculate productivity growth and its components for a sample of farms in the Corn Belt and three cotton regions over the period 1996-1999 using USDA ARMS survey data. The procedures used to create this data are described in Dubman. Our measure of agricultural output is farm output in dollars per farm calculated as the sum of the value of sales, government payments and net CCC loans (augmented by off-farm income in the off-farm model). Our measure of off-farm output is the wages and salaries reported in the ARMS survey. Turning to the inputs, expenditures on labor used annually are our measure of labor; expenditures on gasoline, diesel fuel and other fuels per farm are our measure of fuel; expenditures on fertilizer, lime and other chemicals per farm are our measure of fertilizer; expenditures on seed, feed and miscellaneous operating expenses are our measure of miscellaneous inputs; the annualized flow of capital services (10 year time horizon discounted at 10 percent) from assets (excluding land) is our measure of machinery; and the annualized flow of quality-adjusted services from land (20 year time horizon discounted at 10 percent) valued at the quality-adjusted price of land is our measure of land (see Nehring et.al. for a description of the hedonic model employed to adjust for land quality) All variables are deflated by the estimated increase or decrease in cost of production in 1997-1999 compared to 1996 (Agricultural Prices).

Our method constructs a best-practice frontier from the data in the sample (i.e., we are constructing regional frontiers in the Corn Belt and selected cotton states and comparing individual state-level cohorts to that frontier). Technology in any given time period is represented by an input distance function. We have only one aggregate output for our "farm business" model and two outputs for our off-farm model.

A summary of the sample data is presented in tables 3 and 4. The sizes of farms are only somewhat larger in the cotton states than in the Corn Belt averaging 558 in the cotton states compared to 455 acres in the Corn Belt. In the Corn Belt average farm size by group varies from 114 acres in the limited resource typology to 2230 in the very large family farm group. In the cotton states the average farm size by group varies from 128 acres in the limited resource group to 2293 acres in the very large family farm group. Off-farm income is highest, in aggregate and per acre, in the residential typology in both regions. Off-farm income is lowest per acre in the large family farms and very large family farm groups in both regions. Labor use per farm and per acre is higher in the cotton states where cropping activities are relatively labor intensive--$65.93 per acre in the Corn Belt on average, compared to $79.75 per acre, on average in the cotton states. The use of machinery ($38.46 per acre in the Corn Belt and $43.18 per acre in the cotton states) and costs/acre of most other inputs are also higher in the cotton states than in the Corn Belt. The average age of farmers is highest in retirement and low sales groups in both regions while the average age of farmers is, in general, lowest in the residential and higher sales farm groups in both regions.

We calculate Malmquist productivity indexes as well as the efficiency-change, technical-change, pure technical efficiency-change (technical efficiency change under variable returns to scale), and scale-change components for each cohort in our sample. We measure Malmquist productivity indexes using a program developed by Coelli (1996). Tables 5 and 6 summarize the results at the state level and for small and large farm groups, where reported values are geometric means of cohort results. If the value of the Malmquist index or any of its components is less than 1, that means regress or deterioration in performance, whereas values greater than 1 mean improvements in the relevant performance. These measures capture performance relative to the best practice in the sample, where best practice represents a frontier for the Corn Belt or for selected cotton states, and the farms selected in our samples define the region. Looking first at the bottom of table 5, we see that, on average, productivity in the Corn Belt increased at a rate of 2.73 percent for the 1996-

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3 Subtracting 1 from the number reported in the table, and multiplying by 100 gives average percent increase or decrease per annum for the relevant performance measure.

1999 period for the cohorts in our sample[3]. On average, the growth was due to innovation (techch) rather than improvements in efficiency (effch) or catching-up. In contrast, we see that on the bottom of table 6 that, on average, productivity in the selected sample of farms in cotton states decreased at an average rate of 1.1 percent for the 1996-1999 period for the cohorts in our sample.

If we compare the performance of all large farms to all small farms we find that productivity of large Corn Belt farms increased at a 0.3 percent higher average annual rate than that of small farms. In the cotton states the average annual productivity growth of small farms outstripped that of large farms by about 6 percent. Finally, we note that inclusion of off-farm income as an additional output boosts total factor productivity by about one-half of one percent on average in the Corn Belt, but reduces productivity by a similar amount in the cotton states[4].

Turning to the state-by-state results, we note that in the Corn Belt, Minnesota has the highest total factor productivity change in the sample at 6.69 percent per year on average, evenly distributed between improvements in innovation and efficiency. Most states have positive growth in total factor productivity. However, three states, Illinois, Missouri, and South Dakota exhibit significant losses in efficiency and therefore in total factor productivity. And small farms show significant deterioration in total factor productivity in Iowa and Wisconsin.

The largest gaps between total factor productivity growth in large versus small farms occurs in Missouri, Minnesota, South Dakota, and Wisconsin. Large farms strongly outperform small farms in Minnesota and Wisconsin, while small farms greatly outperform large farms in Missouri and South Dakota. In the cotton states Georgia has the highest total factor productivity change in the sample, mostly due to improvements in technical efficiency. North Carolina, South Carolina and Texas come close to matching Georgia's performance. Three states, Louisiana, Oklahoma, and Tennessee exhibit significantly lower average total factor productivity than that for the entire sample. The largest gaps between total factor productivity growth in large versus small farms occurs in Arkansas, Georgia, and South Carolina where small farms outperform large farms in by a wide margin. Large farms outperform small farms only in Tennessee and Virginia, and by only a small margin.

To analyze structural factors influencing efficiency changes we estimate regressions with efficiency changes as dependent variables and cohort characteristics as independent variables as shown in tables 7-9. The Malmquist analysis provides estimates of technical efficiency change, technical change, pure technical efficiency change, scale efficiency, and total factor productivity change; and these five indices are used separately as dependent variables. The independent variables include size (acres operated), enterprise mix (livestock/crop ratio), and typology group (a dummy variable equal to 1 for small farms and zero for large farms).

The regressions in table 7 reveal that for the Corn Belt total factor productivity growth is positively associated with the livestock/crop ratio, and negatively associated with farm size. New technology involved in livestock enterprises appears to represent the innovation efficiency presented in table7. Both variables are significant at close to the five- percent level. Note that the small farm dummy is significant for the pure technical efficiency and scale efficiency effects. The residual scale component captures changes in the deviation between the variable-returns and constant-returns to scale technology; such deviations are relatively large for small farms. The regressions in tables 8-9 in the cotton states reveal that total factor productivity growth is negatively associated with the livestock/crop ratio in the Southern Seaboard and in the Prairie Gateway, and also negatively associated with acres operated in the Southern Seaboard. Finally, we note that innovation is negatively associated with small farms in the Prairie Gateway and Southern Seaboard.

Summary and Conclusions: Given recent concerns expressed about the structural transformation of agriculture and the health of the family farm this study provides a measure of the economic health of small and large farms at the state level (Harl, National Commission on Small Farms). Using nonparametric measures of total factor productivity we identify the relative

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4 We deflated off-farm income by the index of prices paid for labor.

success of family farms (annual sales of less than $250,000) in terms of productivity rankings by region. Minnesota exhibits the strongest growth in the Corn Belt, Georgia in the cotton states analyzed. In the Corn Belt, the gap between small and large farms' average annual productivity growth is largest in Missouri, Minnesota, South Dakota, and Wisconsin, favoring large farms in Minnesota and Wisconsin and small farms in Missouri and South Dakota. In the cotton states the gap in average annual productivity growth is largest in Arkansas, Georgia, and South Carolina, strongly favoring small farms. And, we summarize the importance of factors that influence technical efficiency on farms by size and typology showing that typology, acres operated and the livestock /crop ratio are factors influencing total factor productivity growth. In the Corn Belt productivity growth is positively related to the livestock/crop ratio, while the evidence in the cotton states suggests a negative association of productivity growth and the livestock/crop ratio. Acres operated appear to be negatively associated with productivity growth in both regions. Finally, in future research we will compare our micro data productivity results with those derived from state level aggregates.

Our results identify particularly weak economic performance of small farms in Iowa, Louisiana, Oklahoma, and Wisconsin and of large farms in Missouri, Oklahoma, and South Carolina. Our results also indicate strong performance of small farms in several states. Thus, these results give policy makers a more detailed and up to date view of the overall economic health of the agricultural sector in the states analyzed than has previously been possible with aggregate state level analyses.

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Figure1. Defining the Farm Typology Groups

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

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

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

Other Farms

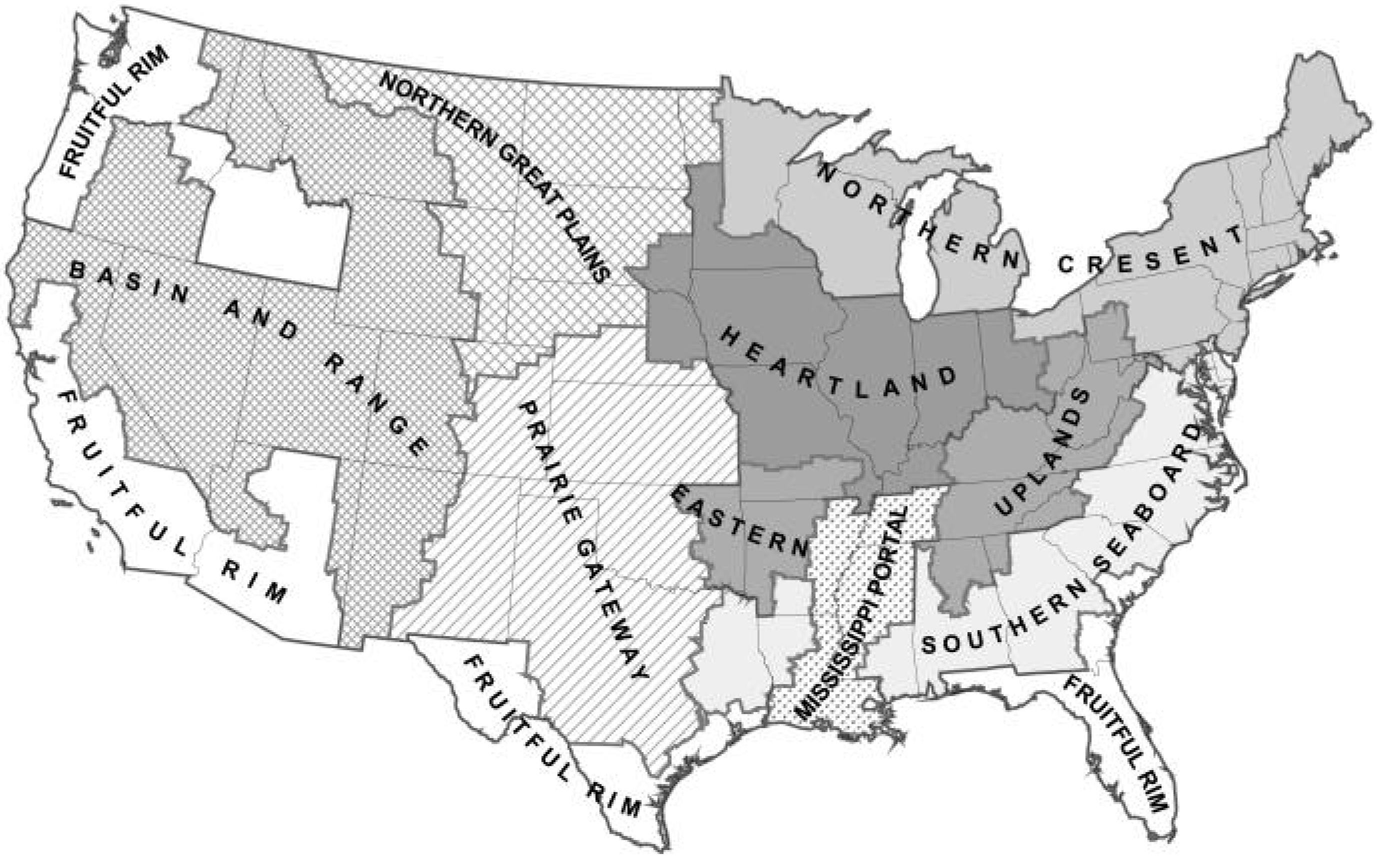
6. **Large family farms.** Sales between $250,000 and $499,999.

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

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

Figure 2. Farm Resource Regions



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

Table 1. Number of Farms and Size of Farms, Hog Numbers, and Population Growth

Region	No. of Farms 1980	No. of Farms 1997	Land in Farms 1980	Land in Farms 1997	Acres Per Farm 1980	Acres Per Farm 1997	Change in Hog Numbers 90/99	Change in Pop 1990/2000
	-----1000----		---1000 acresB				%	%
Heartland	529	411	127,200	122,000	241	297	-6.9	8.4
Mississippi Portal	151	121	41,200	34,700	273	287	6.3	10.0
Prairie Gateway	258	308	173,400	165,500	672	537	300.0	16.3
Southern Seaboard	320	229	61,000	46,665	191	204	111.8	17.5

Source: U.S. Department of Commerce, Bureau of Census, Census of Agriculture 1992. U.S. Dept. of Agriculture, National Agricultural Statistics Service, Census of Agriculture 1997

Table 2: Percent Change in Population Corn and Cotton States Analyzed 1990-2000

	Corn Belt				Cotton States		
	East		West		East		West
Illinois	8.6	Iowa	5.4	Alabama	10.1	Arkansas	13.7
Indiana	9.7	Minnesota	12.4	Georgia	26.4	Louisiana	5.9
Michigan	6.9	Missouri	9.3	North Car	21.4	Mississippi	10.5
Ohio	4.7	Nebraska	8.4	South Car	15.1	Oklahoma	9.7
Illinois	8.6	Iowa	5.4	Virginia	14.4	Tennessee	16.7
						Texas	22.8
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Average	7.9		8.8		17.48		13.21

Source: New York Times, December 29, 2000. P A18.

Table 3: Summary Statistics for Variables in Corn Belt Business and Off-farm Models 1999

Type	Farms %	Area %	Output	Labor	Fuel	Fert	Misc	Mach	Govt	Off-Fm In	Land $/Ac	Acres	Age	Ed	GMO Corn %	GMO Soy %
			Thousand Dollars													
Limited Resouce	3.7	1.1	15.6	15.8	0.8	1.9	5.0	4.9	2.3	8.7	1155	129	53.8	1.8	0.27	0.31
Retirement	9.0	2.3	20.3	13.9	0.9	1.8	4.8	6.9	2.1	11.0	1499	114	67.8	2.4	0.12	0.12
Residental/ lifestyle	32.3	10.1	26.9	13.6	1.2	3.4	5.6	7.3	3.1	55.3	1430	144	48.2	2.7	0.17	0.30
Farming/ lower sales	26.1	18.4	50.8	29.7	2.4	6.0	11.6	13.5	6.8	17.8	1298	321	58.1	2.1	0.17	0.29
Farming/ higher sales	14.8	23.8	169.8	55.7	6.6	20.5	39.8	39.2	25.1	16.0	1378	732	49.2	2.5	0.23	0.32
Large family farms	6.4	16.2	333.2	89.8	12.8	44.1	72.4	71.7	48.0	18.8	1448	1158	48.0	2.7	0.27	0.26
Very Large Family Farms	3.0	14.6	898.3	209.1	28.7	80.4	300.1	138.6	83.1	17.8	1457	2230	49.4	2.8	0.26	0.32
Nonfamily Farms	1.2	1.7	469.5	221.6	14.1	30.6	180.1	65.9	19.9	0.0	1657	671	54.3	3.1	0.39	0.40
All Farms	100.0	100.0	109.9	30.0	3.8	13.9	34.3	17.5	13.3	28.7	1383	455	51.4	2.4	0.17	0.30

Table 4: Summary Statistics for Variables in the Cotton States Business and Off-farm Models 1999

Type	Farms %	Area %	Output	Labor	Fuel	Fert	Misc	Mach	Govt	Off-Fm In	Land $/Ac	Acres	Age Fm	Ed	GMO Corn %	GMO Soy %
			----------------------Thousand Dollars--------------------													
Limited Resouce	9.0	2.1	21.2	15.9	----	----	9.1	5.3	2.0	3.7	604	128	58.9	1.9	0.44	0.34
Retirement	9.1	2.6	25.6	14.3	----	----	6.8	3.7	2.2	6.0	786	152	71.0	2.1	0.12	1.00
Residental/ lifestyle	28.9	10.3	74.5	33.0	----	----	11.4	5.2	3.3	48.6	730	200	49.5	2.8	0.48	0.56
Farming/ lower sales	25.9	19.1	74.4	29.8	----	----	21.3	12.1	7.2	16.6	696	411	59.4	2.3	0.48	0.37
Farming/ higher sales	12.2	18.5	230.1	48.4	----	----	87.8	40.2	33.7	19.1	577	860	51.4	2.5	0.32	0.50
Large family farms	6.8	16.2	427.8	63.8	----	----	161.9	66.7	56.8	17.9	598	1338	50.5	2.6	0.28	0.50
Very Large Family Farms	5.4	19.4	1,167.1	113.2	----	----	381.3	142.7	109.9	25.2	649	2293	49.7	2.8	0.40	0.63
Nonfamily Farms	2.9	9.1	437.2	278.5	----	----	181.8	55.7	44.3	0.0	509	1725	47.6	2.7	0.48	0.65
All Farms	100.0	100.0	177.6	44.5	----	----	57.7	24.1	18.3	24.1	677	558	55.1	2.5	0.37	0.55

Table5: Corn Belt: MALMQUIST INDEX SUMMARY OF FIRM MEANS

State	effch5	techch	pech	sech	tfpch
Illinois					
small	0.981	1.046	0.901	1.089	1.026
large	0.963	1.012	0.962	1.001	0.976
total	0.971	1.028	0.933	1.041	0.998
Indiana					
small	0.960	1.212	0.893	1.075	1.077
large	1.000	1.033	1.001	0.998	1.033
total	0.981	1.073	0.950	1.002	1.053
Iowa					
small	0.939	1.051	0.933	1.005	0.986
large	0.989	1.035	0.990	0.999	1.023
total	0.965	1.042	0.964	1.002	1.006
Michigan					
small	0.998	1.029	0.915	1.090	1.028
large	1.042	1.038	1.038	1.004	1.081
total	1.021	1.034	0.980	1.043	1.056
Minnesota					
small	0.988	1.028	0.927	1.066	1.016
large	1.074	1.036	1.060	1.013	1.112
total	1.033	1.032	0.996	1.037	1.067
Missouri					
small	0.985	1.046	0.940	1.048	1.030
large	0.887	1.048	0.894	0.992	0.939
total	0.931	1.046	0.915	1.017	0.974
Nebraska					
small	0.958	1.056	0.940	1.019	1.012
large	0.993	1.044	0.988	1.004	1.036
total	0.977	1.050	0.966	1.011	1.025
Ohio					
small	0.990	1.061	0.943	1.050	1.051
large	0.984	1.048	1.030	0.956	1.032
total	0.987	1.054	0.989	0.998	1.040
South Dakota					
small	0.994	1.030	0.982	1.023	1.023
large	0.905	1.006	0.871	1.039	0.911
total	0.945	1.017	0.916	1.032	0.961
Wisconsin					
small	0.942	1.014	0.913	1.031	0.955
large	1.086	1.020	1.087	0.999	1.108
total	1.017	1.017	1.003	1.014	1.035

5 . Efficiency Change (effch), technical change (techch), pure technical efficiency change (pech), scale efficiency change (sech), and total factor productivity (tfpch).

mean	0.984	1.044	0.955	1.030	1.027

Table6 Cotton States: MALMQUIST INDEX SUMMARY OF FIRM MEANS

State	effch[6]	techch	pech	sech	tfpch
Alabama					
small	1.225	0.841	1.060	1.167	1.031
large	1.012	0.912	1.011	1.002	0.923
total	1.135	0.869	1.034	1.098	0.986
Arkansas					
small	1.272	0.819	1.037	1.226	1.042
large	1.023	0.856	1.006	1.016	0.876
total	1.166	0.834	1.025	1.137	0.972
Georgia					
small	1.316	0.861	1.135	1.160	1.133
large	0.966	0.929	0.985	1.012	0.926
total	1.178	0.888	1.072	1.098	1.046
Louisiana					
small	1.072	0.894	0.976	1.099	0.958
large	1.014	0.940	0.984	1.030	0.953
total	1.048	0.912	0.978	1.071	0.956
Mississippi					
small	1.117	0.876	0.992	1.125	0.978
large	1.055	0.923	1.054	1.001	0.974
total	1.092	0.894	1.017	1.074	0.977
North Carolina					
small	1.259	0.841	1.073	1.174	1.059
large	1.160	0.873	1.136	1.020	1.012
total	1.218	0.853	1.100	1.110	1.040
Oklahoma					
small	1.140	0.814	1.089	1.047	0.928
large	0.989	0.928	0.991	0.998	0.918
total	1.077	0.858	1.049	1.027	0.924
South Carolina					
small	1.253	0.868	1.099	1.141	1.089
large	1.090	0.859	1.063	1.026	0.937
total	1.185	0.865	1.084	1.093	1.025
Tennessee					
small	1.175	0.819	1.097	1.070	0.962
large	1.108	0.878	1.048	1.058	0.973
total	1.148	0.842	1.077	1.065	0.966
Texas					
small	1.282	0.805	1.139	1.126	1.032
large	1.068	0.934	1.049	1.018	0.997
total	1.191	0.854	1.102	1.081	1.018
Virginia					
small	1.121	1.863	1.011	1.108	0.967
large	1.127	0.890	1.082	1.042	1.003

total	1.123	0.873	1.039	1.081	0.981
mean	1.141	0.867	1.052	1.085	0.989

6 . Efficiency Change (effch), technical change (techch), pure technical efficiency change (pech), scale efficiency change (sech), and total factor productivity (tfpch).

Table 7: Regression models of changes in efficiency

Corn States

Variable	Malmquist indices: TE Change	Technical Change	Pure Tech Eff change	Scale Eff	TFP Change
1997 dummy	1.475	0.711	1.309	1.109	1.018
	(18.42)	(25.85)	(32.01)	(25.76)	(56.86)
1998 dummy	0.951	0.945	1.036	0.919	0.915
	(11.91)	(34.43)	(25.42)	(21.45)	(52.13)
1999 dummy	0.698	1.813	0.793	0.910	1.280
	(8.48)	(64.05)	(18.85)	(20.57)	(52.31)
Region (West dum)	0.059	0.009	0.011	0.022	0.051
	(0.90)	(0.37)	(0.32)	(0.63)	(7.70)
Type (Small dum)	0.079	0.377	-0.071	0.129	0.023
	(1.08)	(1.49)	(1.89)	(3.26)	(1.69)
Livestock/crops	0.052	-0.037	0.063	-0.012	0.058
	(1.38)	(2.84)	(3.26)	(0.57)	(1.98)
Acres	-0.0001	-0.0001	-0.0001	0.00002	-0.000047
	(1.41)	(1.13)	(2.58).	(0.98)	(4.27)
R^2	0.224	0.833	0.322	0.100	0.129
No. of obs.					

t-statistics in parenthesis.

Table 8: Regression models of changes in efficiency

	Prairie Gateway				
	Mamquist indices				
Variable	TE Change	Technical Change	Pure Tech Eff change	Scale Eff	TFP Change
1997 dummy	1.233	0.814	1.077	1.147	0.989
	(7.98)	(19.73)	(10.72)	(12.24)	(7.99)
1998 dummy	1.191	0.916	1.203	0.995	1.077
	(7.10)	(20.43)	(11.02)	(9.77)	(8.01)
1999 dummy	1.082	1.034	1.160	0.931	1.134
	(6.75)	(24.17)	(11.13)	(9.58)	(8.84)
Type (Small dum)	0.177	-0.103	0.057	0.106	0.014
	(1.42)	(3.11)	(0.71)	(1.41)	(0.14)
Livestock/crops	-0.077	-0.0001	-0.062	-0.012	-0.062
	(1.28)	(0.07)	(1.57)	(0.32)	(1.28)
Acres	-0.0002	0.0005	-0.00002	-0.00005	-0.000008
	(0.42)	(0.48)	(0.65).	(0.08)	(0.25)
R^2	0.138	0.554	0.118	0.196	0.072
No. of obs.					

t-statistics in parenthesis.

Table 9 Regression models of changes in efficiency

Southern Seaboard					
	Mamquist indices				
Variable	TE Change	Technical Change	Pure Tech Eff change	Scale Eff	TFP Change
1997 dummy	1.666	0.789	1.363	1.262	1.245
	(12.42)	(20.66)	(14.84)	(13.13)	(13.34)
1998 dummy	1.235	0.865	1.236	0.983	1.053
	(9.20)	(22.62)	(13.44)	(10.22)	(11.26)
1999 dummy	1.067	1.193	1.220	0.848	1.265
	(8.23)	(32.31)	(13.75)	(9.14)	(14.02)
Type (Small dum)	0.126	-0.052	-0.051	0.183	0.010
	(1.22)	(1.78)	(0.73)	(2.48)	(0.14)
Livestock/crops	-0.019	-0.0002	-0.033	0.015	-0.022
	(0.56)	(0.17)	(1.45)	(0.62)	(0.95)
Acres	-0.0002	-0.00003	-0.00013	-0.00005	0.0001
	(2.13)	(1.49)	(2.47).	(0.36)	(2.61)
R^2	0.212	0.559	0.068	0.096	0.234
No. of obs.					

t-statistics in parenthesis.

Table 10 Regression models of changes in efficiency

Mississippi Portal

Variable	TE Change	Technical Change	Pure Tech Eff change	Scale Eff	TFP Change
	Mamquist indices				
1997 dummy	1.406	0.753	0.976	1.430	1.053
	(6.47)	(15.40)	(11.71)	(7.82)	(5.84)
1998 dummy	1.010	0.853	0.937	1.077	0.852
	(4.99)	(18.75)	(12.18)	(6.33)	(5.08)
1999 dummy	1.104	1.409	1.126	0.989	1.196
	(5.73)	(17.33)	(15.38)	(6.10)	(7.49)
Type (Small dum)	0.164	-0.021	-0.008	0.152	0.104
	(1.02)	(0.56)	(0.13)	(1.12)	(0.78)
Livestock/crops	-0.002	0.0006	0.0004	-0.0002	-0.00006
	(0.43)	(0.61)	(0.26)	(0.62)	(0.18)
Acres	-0.000006	0.00002	0.00003	-0.00005	-0.000003
	(0.73)	(0.73)	(0.55).	(1.18)	(0.39)
R^2	0.099	0.503	0.114	0.159	0.091

No. of obs.

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t-statistics in parenthesis.