Determinants of Farm Size and Structure

Proceedings of the program sponsored by the NC-181 Committee on Determinants of Farm Size and Structure in North Central Areas of the United States, held January 6, 8, and 9, 1990, in Albuquerque, New Mexico.

Iowa State University
Ames, Iowa 50011
December 1990

COST DISTRIBUTION AND EFFICIENCY OF CORN PRODUCTION

Mary Ahearn, Gerald Whittaker and Dargan Glaze*

During the 1980's, normal U.S. production of corn has been about 7 billion bushels per year. A great deal of variation exists in the bundle of inputs used to produce corn. For example, in 1987 the average cash cost of producing a bushel of corn was $1.40, while individual farm costs ranged from less than 80 cents to over $10 per bushel. Correspondingly, efficiency in corn production varies significantly across farms. This paper addresses these issues by first describing the distribution of corn production costs across U.S. farms[1], and then analyzing cost and efficiency levels by farm size.

Data Source

The Corn Version of the 1987 Farm Costs and Returns Survey (FCRS) is the source of the primary data. These data are designed to allow for estimation of the costs of inputs used for the corn production only. Some of these costs, the machine-related costs, are estimated with the use of a "budget generator". The budget generator, in conjunction with accepted accounting practices for other inputs, has historically been used by the USDA and land-grant universities to estimate costs in an aggregated fashion, for example at the state level. A budget generator has now been developed at a disaggregated, farm-level, which permits more flexibility in analysis (Glaze). Those farm-level data are used in this analysis.

The FCRS data are the first data ever available which are statistically representative of the cost of producing corn in the U.S. The FCRS has been conducted annually by ERS and the National Agricultural Statistics Service (NASS) beginning with the 1985 survey for calendar year 1984. Each year there are multiple versions of the FCRS: an in-depth, whole-farm version and commodity cost-of-production versions. All versions have questions about whole-farm expenses and income in common; each cost-of-production version gathers detailed information about input use, field operations, and production costs of a particular crop. Because of survey costs, USDA cannot undertake detailed surveys of every commodity in every year; the FCRS covers each commodity about every four years. The 1987 FCRS is the first time that corn data have been collected under the FCRS system. The FCRS has replaced the old Cost of Production (COP) surveys which were jointly conducted by ERS

---

*Agricultural Economists, Economic Research Service, USDA. Paper presented at the NC-181 Meeting, Albuquerque, NM, January 6, 1990.

[1]Similar analysis is underway for other major row crops, for example, see Ahearn, et al.

and NASS. Unlike the FCRS, the COP surveys were not probability-based surveys and, hence, were not statistically representative of the cost of production.

The FCRS is a multiframe stratified survey. The sample is drawn randomly from stratified list and area frames. For a particular cost-of-production version the list frame is made up of farms known to have previously produced the commodity. The list frame is stratified by size. The area frame is made up of land segments and is stratified by land use. Each farm sampled represents a number of similar farms, the particular number being the survey expansion factor, which is the inverse of the probability of the sampled farm being selected. Data are expanded by the survey expansion factors to produce estimates for the population of all farms producing the commodity.

Survey questions are developed jointly by NASS and ERS. The survey questionnaires are filled out by NASS enumerators in personal interviews with farmers. The FCRS is undertaken during February and March with questions being asked about production in the previous year.

The U.S. Distribution of Corn Production Costs

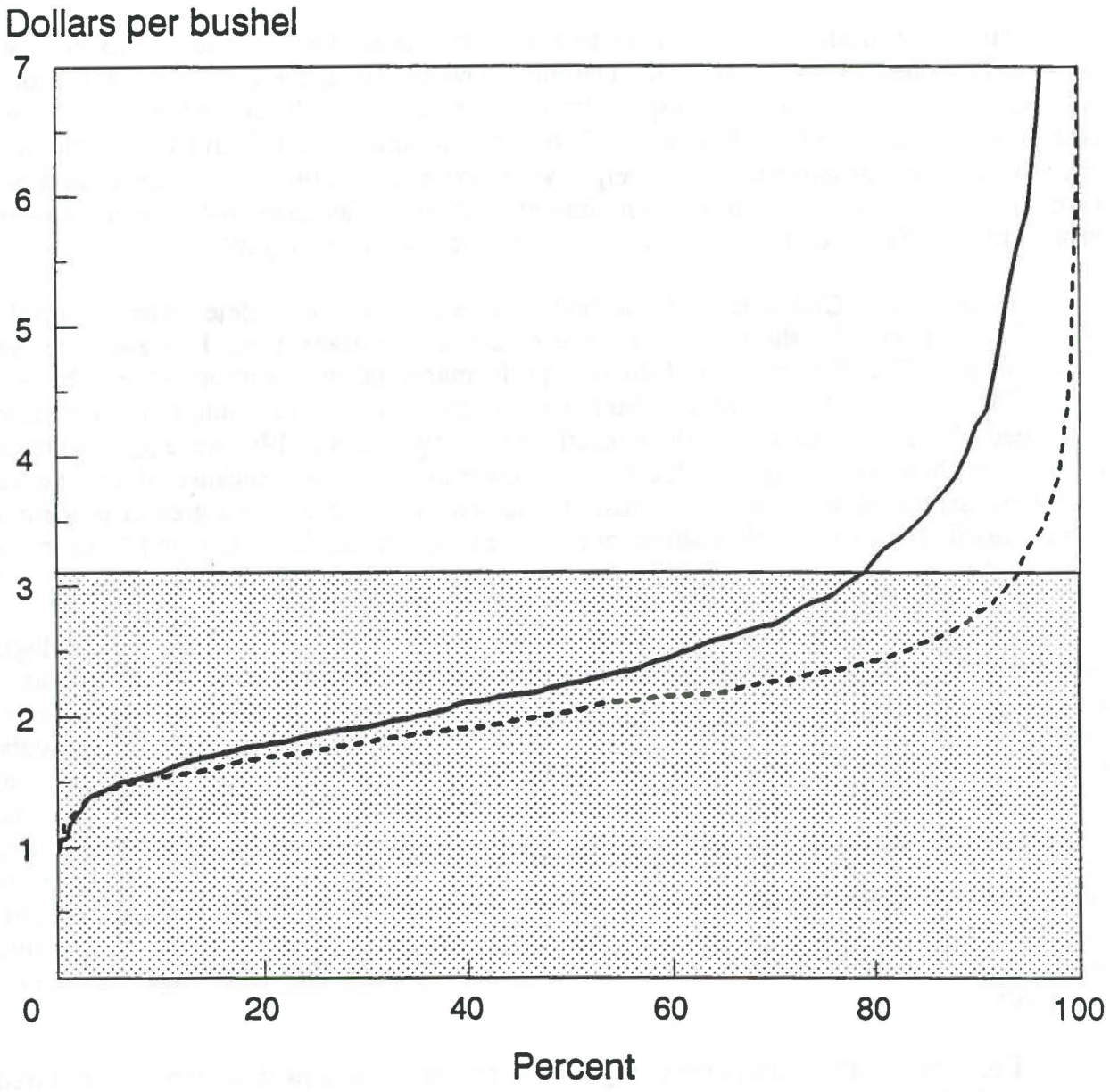
The 1987 FCRS Corn Version accounted for 482,500 farms producing corn, representing 48.7 million planted acres, and 5.8 billion bushels of corn. Figure 1 shows how farms and production are distributed by level of economic cost, as well as how those distributions relate to the 1987 target price.[2] Information about the distribution of costs is critical for gauging the potential impacts of policies, such as the level of target prices, prior to their implementation. In 1987, the participation rate for the corn program was 90 percent and the target price was set at $3.03 per bushel. Ninety percent of farms had cash costs below this level and 77.3 percent of farms had economic costs below this level. These farms represented 98.5 and 93.1 percent of corn production with cash and economic costs, respectively, below the established target price.

The average economic cost of production was $254 per acre or $2.15 per bushel in 1987. Given the wide variation in cost levels, it is of interest to examine the relationships between costs and other variables, such as size. One arbitrary, but useful, way to examine the characteristics of the 482,500 corn-producing farms is to delineate them into low, mid-range, and high levels of costs of production. These classifications can be made with costs on a per-acre or per-bushel basis. We have taken a per-bushel approach because of the

[2]The financial accounting of costs of production follows the USDA approach. This approach accounts for cash costs, capital replacement, and economic costs. Economic costs include cash costs (excluding interest) plus an imputation for the opportunity costs of owned inputs. (See the Appendix for more information on the accounting methods.)

Figure 1

Cumulative distribution of economic production costs for corn, 1987



Source: 1987 Farm Costs and Returns Survey

wide variation in normal per-acre yields across the U.S. and because of the obvious economic importance of input costs relative to output.

Low-cost farms are defined as those with economic costs per bushel in the lower quartile for the U.S., the high-cost farms as those in the upper quartile, and the 50 percent of farms in the mid-range of costs as the mid-cost producers. Twenty-five percent of farms had economic costs below $1.87, while twenty-five percent of farms had economic costs of $2.90 and above in 1987.

High-cost producers can be classified as such because their per-acre costs are high, because their yields are low, or both. The most obvious difference among the cost groups is the difference in average yields, especially for the high-cost producers (table 1). The high-cost producers averaged yields of about 70 bushels, compared to 135 and 120 for the low-cost and mid-cost producers, respectively. When you examine the cost structure on a per-acre basis, the high-cost group barely maintains their higher average costs but the low-cost group still has significantly lower costs than the other two groups (table 2).

Because the FCRS data are for a single year, we are unable to determine if the yields of 1987 were typical for the individual farms or a one-year aberration. However, the best indicator the FCRS data provide of the past performance of an operation is the debt-asset ratio. This is because farms who consistently experience low returns would tend to be more leveraged. In fact, we found that the operations with high costs in 1987 were <u>less</u> leveraged on average than the average producer in the lower cost groups. Because of the income problems associated with their low yields, the high-cost group did have a greater percent of farms classified in a vulnerable position of negative incomes coupled with high (0.4 or more) debt-asset ratios.

In order to uncover the relationships masked by the averages, particularly in the high-cost group of producers, we have classified the corn yields of farms as low or high relative to other farms in 1987. Farms were classified as low-or high-yielding based on whether or not they were below or above the median yield for their state as reported by the FCRS data. For the low-cost group, two out of three producers had high yields. The mid-cost group was evenly split between high- and low-yielding farms. For the high-cost group, less than 1 out of 5 producers had yields above the median for their state. Some of the more interesting results pertain to the producers at the extremes and raise questions that we are unable to adequately address with the FCRS data set. For example, are the producers with low per-bushel costs and with low yields at the forefront of low-input, alternative agriculture technology? Are those with high per-bushel costs but with high yields aggressive, new entrants?

The most notable difference in input costs across the groups is for labor, both hired and unpaid. Several other inputs contribute to the cost differences: custom work, repairs, and capital replacement. Although their yields, were higher on average, the low-cost group of producers had lower per acre costs of fertilizer and chemicals.

Table 1--Characteristics of corn farm operations, by economic cost levels, 1987

Item	Economic Cost Class			
	Low-Cost Producer	Mid-Cost Producer	High-Cost Producer	All farms
Sample n:	279	629	314	1,222
Number of farms:	120,592	241,539	120,369	481,500
Share of all farms:	24.99%	50.06%	24.94%	100.00%
Corn characteristics				
Average planted acres	123	112	56	101
Yield (bu./acre)	135.84	120.92	69.26	118.25
Variable expense as a % of total	46.67%	44.86%	50.53%	46.16%
			Percent	
Whole farm characteristics				
Production Specialty:				
Cash grain	49.18%	55.32%	37.05%	49.23%
Other crop	3.74%	5.47%	19.42%	8.52%
Beef, hog, sheep	27.07%	20.21%	24.73%	23.05%
Dairy	19.10%	18.24%	17.98%	18.38%
Other livestock	0.89%	0.73%	0.80%	0.79%
% with any livestock	68.19%	64.07%	65.48%	65.45%
Region:				
Northeast	8.29%	6.69%	12.30%	8.49%
Southeast	1.99%	6.74%	41.41%	14.20%
Corn Belt	75.00%	75.19%	37.68%	65.79%
Northern Plains	14.40%	10.24%	5.57%	10.11%
West	0.28%	1.12%	3.01%	1.38%
Financial Position:				
Favorable	62.98%	68.24%	63.69%	65.88%
Marginal Income	17.20%	11.00%	19.38%	14.64%
Marginal Solvency	15.27%	14.62%	9.46%	13.50%
Vulnerable	4.52%	5.94%	7.46%	5.97%
Operator Characteristics				
Average age	52	51	51	51
Age distribution:				
<25	0.74%	0.99%	3.99%	1.68%
26-49	46,41%	44.29%	36.69%	42.93%
50-65	32.77%	38.71%	40.41%	37.65%
>65	20.05%	15.98%	18.90%	17.72%
Major occupation:				
Farming	82.76%	84.66%	69.99%	80.52%
Other	17.23%	15.33%	30.00%	19.47%
Farm organization:				
Partnership	9.11%	10.10%	8.17%	9.37%
Individual	86.97%	86.49%	88.32%	87.07%
Corp and Coop	3.90%	3.40%	3.49%	3.55%
Economic class:				
$0-$39,999	3.59%	5.77%	1.65%	11.03%
$ 40,000-$99,999	7.18%	12.2%	3.02%	22.43%
$100,000-$249,999	7.17%	13.84%	4.08%	25.11%
$250,000 OR MORE	7.01%	18.20%	16.15%	41.39%

% receiving any govt. payments	78.22%	74.39%	51.30%	69.59%
			Dollars	
Per farm finances				
Sales	95,150	77,638	54,241	76,178
Government payments	16,511	13,714	7,001	12,738
Other farm related income	693	742	946	781
Net cash income	40,230	23,860	15,184	25,787
Net farm income	26,841	20,142	14,347	20,370
Off-farm income	14,730	16,795	20,002	17,079
Assets	452,349	383,627	295,711	378,870
Debt	86,930	78,449	44,711	72,152

Table 2--U.S. corn production costs per acre, by cost level, 1987

Item	ECONOMIC COST CLASS			
	LOW-COST PRODUCER	MID-COST PRODUCER	HIGH-COST PRODUCER	All farms
Sample n:	279	629	314	1,222
Number of farms:	120,592	241,539	120,369	482,500
Share of all farms:	24.99%	50.06%	24.94%	100.00%
Yields per acre	136	121	69	118
Gross value of production	207.35	190.13	114.78	184.85
Cash expenses:				
Seed	19.07	19.36	19.82	19.34
Fertilizer	30.91	39.04	38.60	36.51
Lime and Gypsum	1.11	2.91	2.73	2.34
Chemical cost	18.75	19.76	22.30	19.81
Custom Operation	5.51	6.69	9.92	6.78
Fuel, lube, and electricity	7.09	8.25	10.88	8.26
Repairs	9.19	10.40	12.91	10.38
Hired labor	5.35	7.46	10.83	7.29
Purchased irrigation water	0.22	0.06	0.87	0.22
Drying	4.60	4.77	2.37	4.39
Technical service	0.16	0.33	0.18	0.26
Irrigation	1.12	2.09	1.18	1.67
Total, variable expenses	103.10	121.11	132.60	117.24
General farm overhead	11.13	11.30	11.12	11.22
Taxes and insurance	17.71	20.50	18.47	19.37
Interest on operating loans	5.04	6.00	4.08	5.44
Interest on real estate	10.99	11.40	8.83	10.92
Irrigation	0.63	0.79	0.46	0.70
Total, fixed cash expenses	45.50	49.99	42.96	47.65
Total, cash expenses	148.60	171.10	175.56	164.88
Capital replacement	16.54	18.54	21.13	18.29
Economic costs:				
Variable cash expenses	103.10	121.11	132.60	117.24
General farm overhead	11.13	11.30	11.12	11.22
Taxes and insurance	17.71	20.50	18.47	19.37
Capital replacement	16.54	18.54	21.13	18.29
Opportunity costs of owned inputs:				
Operating capital	2.08	2.45	2.69	2.37
Nonland capital	8.53	10.09	12.01	9.89
Land	45.40	62.00	35.61	53.28
Unpaid labor	16.39	23.93	28.75	22.31
Total, economic costs	220.88	269.91	262.38	253.96
Net returns:				
Value of production less cash expenses	58.75	19.04	-60.78	19.97
Value of production Less cash expenses and capital replacement	42.21	0.50	-81.90	1.68
Value of production less economic costs	-13.53	-79.78	-147.60	-69.11

Size of corn acreage and size of the whole farm stand out as the other dominant characteristics differentiating cost groups. The differences along these lines are especially evident between the twenty-five percent of farms who make up the high-cost group and the other two groups. High-cost producers had average corn acreage of half or less of the other two groups.

Just as for the U.S. as a whole, farm size is generally related to the major occupation of the farm operator and the proportions of income earned on and off the farm. The average off-farm income of the high-cost group, in contrast to the other two groups, is greater than their farm income, whether farm income is measured on a cash basis (net cash income) or accrual basis (net farm income). Although the total cash income of the high-cost group is less than either the medium or low cost group, their average off-farm income of $20,000 is greater than that of both other groups.

Farm size is a major factor in explaining the differences in the balance sheets of the cost groups for corn production. Lower net worth, lower absolute debt and asset levels, and lower debt-asset ratios of the high cost group are all consistent with the relationships between farm size and financial characteristics that we find for the sector as a whole.

Comparison of the age distribution of the cost groups reflects the typical life cycle in agriculture. The high cost group of generally smaller operations has a higher proportion of very young farmers (less than 25) and older farmers (50 years and older). The high-cost group is likely composed of more farmers entering and exiting farming.

Five major corn regions are defined: the Northeast (CT, DE, ME, MD, NY, PA, and VT), Southeast (AL, KY, LA, NC, SC, TN, VA, and KY), Corn Belt (IL, IN, IA, ,MI, MN, MO, OH, and WI), Northern Plains (CO, KS, NE, ND, and SD), and the West (CA, TX, and WA). Two-thirds of all corn farms are in the Corn Belt. However, three-quarters of all the low-cost producers in the U.S. were in this region. The Northern Plains region had the highest proportion of its corn farms classified as low-cost producers--36 percent.

Costs of Production and Characteristics by Size of Corn Acreage

As mentioned above, size of corn acreage as well as the gross value of farm output are both associated with the cost of producing corn. Table 3 presents characteristics of four sizes of corn operations as defined by corn acreage. Table 4 presents average costs per acre and table 5 presents average costs per bushel by these four size groups. The four size categories are less than 25 acres, 25 to 99 acres, 100 to 499 acres, and 500 or more acres. The FCRS data show that 26 percent of corn-producing farms have an acreage of less than

Table 3--Characteristics of corn farm operations, by size of corn acreage, for the U.S., 1987

Item	Acres of Corn				
	Less than 25	25-99	100-499	500 or more	All farms
Sample n:	217	425	472	108	1,222
Number of farms:	124,683	207,256	135,244	15,317	482,500
Share of all farms:	25.84%	42.95%	28.02%	3.17%	100.00%
Corn characteristics:					
Average planted acres	12	53	190	675	101
% of acres rented	33.10%	44.93%	59.90%	67.16%	53.19%
Yield (bu./acre)	90.64	106.10	121.33	127.58	118.25
Variable expense as a % of total	45.22%	45.47%	45.07%	49.57%	46.16%
			Percent		
Production Specialty:					
Cash grain	35.27%	47.89%	61.02%	76.89%	49.23%
Other crop	12.06%	9.99%	3.77%	1.79%	8.52%
Beef, hog, sheep	32.60%	19.69%	20.44%	13.91%	23.05%
Dairy	18.80%	21.75%	14.12%	7.39%	18.39%
Other livestock	1.25%	0.66%	0.63%	.	0.79%
% with any livestock	63.26%	66.65%	65.37%	67.84%	65.45%
Region:					
Northeast	16.59%	7.34%	3.27%	4.13%	8.49%
Southeast	22.58%	13.94%	7.82%	6.00%	14.20%
Corn Belt	56.26%	66.63%	73.31%	65.40%	65.79%
Northern Plains	3.49%	10.62%	14.11%	21.90%	10.11%
West	1.05%	1.45%	1.46%	2.54%	1.59%
Financial Position:					
Favorable	71.71%	67.41%	59.98%	49.76%	65.88%
Marginal Income	15.80%	12.18%	16.78%	19.58%	14.64%
Marginal Insolvency	6.48%	14.06%	18.18%	21.65%	13.50%
Vulnerable	5.99%	6.34%	5.04%	9.00%	5.97%
Operator Characteristics					
Average age	55	52	49	48	51
Age distribution:					
<25	1.91%	2.72%	0.06%	.	1.68%
26-49	34.69%	39.70%	53.39%	61.21%	42.93%
50-65	38.41%	37.41%	37.77%	33.64%	37.65%
>65	24.97%	20.15%	8.76%	5.14%	17.72%
Major occupation:					
Farming	61.12%	83.14%	92.31%	99.04%	80.52%
Other	38.87%	16.85%	7.68%	0.95%	19.47%
Farm organization:					
Partnership	5.02%	5.93%	15.22%	39.64%	9.37%
Individual	94.49%	92.00%	77.96%	40.30%	87.07%
Corp and Coop	0.47%	2.05%	6.81%	20.05%	3.55%
Economic class:					
$250,000 OR MORE	1.18%	3.84%	23.20%	81.26%	11.03%
$100,000-$249,999	2.67%	21.23%	43.10%	17.29%	22.44%
$ 40,000-$99,999	12.46%	33.55%	26.54%	1.44%	25.11%
$0-$39,999	83.66%	41.37%	7.15%	.	41.39%
% receiving any govt. payments	45.26%	68.44%	90.58%	97.79%	69.59%

			Dollars		
Per farm:					
Sales	23,807	58,472	122,516	322,908	76,178
Government payments	1,660	7,113	24,758	72,905	12,738
Other farm related income	223	697	1,161	3,093	781
Net cash income	6,290	19,267	43,936	112,471	25,787
Net farm income	7,412	17,628	29,176	85,212	20,370
Off-farm income	21,685	16,404	13,413	21,091	17,079
Assets	190,369	316,430	552,210	1,227,643	378,870
Debt	22,040	53,572	120,686	302,944	72,152

Table 4--U.S. corn production costs per acre, by corn acreage class, 1987

Item	Acres of Corn				
	Less than 25	25-99	100-499	500 or more	All farms
Sample n:	217	425	472	108	1,222
Number of farms:	124,683	207,256	135,244	15,317	482,500
Share of all farms:	25.84%	42.95%	28.02%	3.17%	100.00%
Yields per acre	91	106	121	128	118
Gross value of production	146.08	165.58	188.52	201.95	184.85
Cash expenses:					
Seed	18.33	18.26	19.17	21.06	19.34
Fertilizer	31.75	33.55	36.26	40.96	36.51
Lime and Gypsum	1.72	2.61	2.69	1.25	2.34
Chemical cost	19.15	19.37	18.97	22.45	19.81
Custom Operation	15.31	10.82	5.92	3.35	6.78
Fuel, Lube, and electricity	10.69	9.79	7.74	7.59	8.26
Repairs	8.55	9.87	10.38	11.21	10.38
Hired labor	1.79	3.48	7.13	12.55	7.29
Purchased irrigation water	0.00	0.36	0.22	0.10	0.22
Drying	0.65	1.57	4.94	6.56	4.39
Technical service	0.07	0.19	0.24	0.42	0.26
Irrigation	0.08	0.69	1.45	3.49	1.67
Total, variable expenses	108.09	110.56	115.11	130.97	117.24
General farm overhead	20.34	12.63	10.62	9.88	11.22
Taxes and insurance	22.81	19.18	19.28	19.28	19.37
Interest on operating loans	2.54	4.71	6.41	4.23	5.44
Interest on real estate	12.12	9.97	9.82	14.49	10.92
Irrigation	0.06	0.24	0.74	1.17	0.70
Total, fixed cash expenses	57.87	46.73	46.88	49.05	47.65
Total, cash expenses	165.96	157.29	161.99	180.02	164.88
Capital replacement	14.94	17.08	18.71	19.03	18.29
Economic costs:					
Variable cash expenses	108.09	110.56	115.11	130.97	117.24
General farm overhead	20.34	12.63	10.62	9.88	11.22
Taxes and insurance	22.81	19.18	19.28	19.28	19.37
Capital replacement	14.94	17.08	18.71	19.03	18.29
Opportunity costs of owned inputs:					
Operating capital	2.19	2.23	2.33	2.65	2.37
Nonland capital	13.46	12.87	10.06	5.74	9.89
Land	21.91	34.77	58.69	64.14	53.28
Unpaid labor	35.28	33.77	20.57	12.50	22.31
Total, economic costs	239.01	243.11	255.37	264.20	253.96
Net returns:					
Value of production less cash expenses	-19.88	8.29	26.53	21.93	19.97
Value of production less cash expenses and capital replacement	-34.82	-8.79	7.82	2.90	1.68
Value of production less economic costs	-92.93	-77.53	-66.85	-62.25	-69.11

Table 5--U.S. corn production costs per bushel, by corn acreage class, 1987

Item	Acres of Corn				
	Less than 25	25-99	100-499	500 or more	All farms
Sample n:	217	425	472	108	1,222
Number of farms:	124,683	207,256	135,244	15,317	482,500
Share of all farms:	25.84%	42.95%	28.02%	3.17%	100.00%
Yields per acre	91	106	121	128	118
Gross value of production	1.61	1.56	1.55	1.58	1.56
Cash expenses:					
Seed	0.20	0.17	0.16	0.17	0.16
Fertilizer	0.35	0.32	0.30	0.32	0.31
Lime and Gypsum	0.02	0.02	0.02	0.01	0.02
Chemical cost	0.21	0.18	0.16	0.18	0.17
Custom Operation	0.17	0.10	0.05	0.03	0.06
Fuel, Lube, and electricity	0.12	0.09	0.06	0.06	0.07
Repairs	0.09	0.09	0.09	0.09	0.09
Hired labor	0.02	0.03	0.06	0.10	0.06
Purchased irrigation water	0.00	0.00	0.00	0.00	0.00
Drying	0.01	0.01	0.04	0.05	0.04
Technical service	0.00	0.00	0.00	0.00	0.00
Irrigation	0.00	0.01	0.01	0.03	0.01
Total, variable expenses	1.19	1.04	0.95	1.03	0.99
General farm overhead	0.22	0.12	0.09	0.08	0.09
Taxes and insurance	0.25	0.18	0.16	0.15	0.16
Interest on operating loans	0.03	0.04	0.05	0.03	0.05
Interest on real estate	0.13	0.09	0.08	0.11	0.09
Irrigation	0.00	0.00	0.01	0.01	0.01
Total, fixed cash expenses	0.64	0.44	0.39	0.38	0.40
Total, cash expenses	1.83	1.48	1.34	1.41	1.39
Capital replacement	0.16	0.16	0.15	0.15	0.15
Economic costs:					
Variable cash expenses	1.19	1.04	0.95	1.03	0.99
General farm overhead	0.22	0.12	0.09	0.08	0.09
Taxes and insurance	0.25	0.18	0.16	0.15	0.16
Capital replacement	0.16	0.16	0.15	0.15	0.15
Opportunity costs of owned inputs:					
Operating capital	0.02	0.02	0.02	0.02	0.02
Nonland capital	0.15	0.12	0.08	0.05	0.08
Land	21.91	34.77	58.69	64.14	53.28
Unpaid labor	0.39	0.32	0.17	0.10	0.19
Total, economic costs	2.64	2.29	2.10	2.07	2.15
Net returns:					
Value of production less cash expenses	-0.22	0.08	0.22	0.17	0.17
Value of production less cash expenses and capital replacement	-0.38	-0.08	0.06	0.02	0.01
Value of production less economic costs	-1.03	-0.73	-0.55	-0.49	-0.58

25 acres.[3] Only 3 percent are in the largest category of 500 acres or more of corn acreage. However, that largest 3 percent of farms accounted for more than 20 percent of the corn produced in 1987.

As corn acreage increased across the groups, the average yield increased from 91 to 128 bushels per acre. Both cash and economic costs per acre also increased. However, the higher level of costs was more than compensated for by higher yields, so that the largest farms realized an economic cost per bushel of $2.07, compared to the average of all farms of $2.15. The group of smallest corn producers averaged $2.64 in economic costs per bushel, fully 28 percent greater than the group of largest corn producers. The largest corn operations of 500 acres or more and the 100-499 group had almost identical costs per bushel for the most inclusive definition of costs, economic costs. The 100-499 acre corn operations averaged slightly lower cash expenses per bushel due to their lower variable cash expenses.

The major variable expenses are for seed, fertilizer, chemicals, and repairs. On a per-acre basis, all of these input costs increased as the size of the corn operation increased. Capital replacement per acre was also greater on larger operations. Hired labor charges per acre were higher on the large farms, but unpaid labor was less; total paid and unpaid labor charges decreased as farm size increased. Land charges were significantly greater on the larger farms. This is in part because of the higher yields associated with the larger corn operations and the correspondingly higher rent paid as a share of production per acre.

Most farms with small corn acreage were also small farms - more than 80 percent of them had total farm sales and Government payments of less than $40,000. Farms with smaller corn acreage were less likely to specialize in cash grains, and were therefore less likely to receive direct Government payments. One-quarter of operators with corn acreage of 25 acres or less were 65 years old or more. They were less likely to have farming as a major occupation and more likely to be sole proprietorships. Their farm incomes were low and off-farm incomes were high. Their assets, debt, and net worth were all low relative to farms with larger corn acreage.

As the corn acreage class increased in size, the size distribution of farms (in terms of economic class) shifted towards the larger classes. The trends in characteristics across corn acreage classes were easily identified and were similar to other cross-tabulations by farm size that we have done for the category including all U.S. farms.

The above descriptive analysis provides some general insights into the distribution of costs of producing corn, characterizes the producers and their costs for three cost groups, and characterizes the producers and their costs for four corn acreage groups. The

---

[3]According to the 1987 Census of Agriculture, 33.5 percent of corn-producing farms have 25 acres or less of corn.

remainder of the paper will provide a more rigorous test of the relationships involved, with an emphasis on farm size, through an analysis of technical efficiency.

Technical Efficiency of Corn Production

Technical efficiency is defined as the maximum production possible from a given bundle of inputs. Therefore, some reference technology or frontier must be established which is used to establish the efficiency of each producer. There are several ways to measure efficiency. Many studies of farm efficiency use the methodology proposed by Lau and Yotopoulus (1971). In this approach, a functional form of the technology is assumed, and a profit, cost, or production function estimated. Another technique that has been much utilized was developed by Aigner, et al. (1977). By this method, a two component stochastic frontier is estimated as the measure of efficiency. The estimation is based on an assumption of a functional form for the production technology.

We chose the non-parametric technique developed by Fare, et al. (1985). The advantage to this approach is that no assumption of functional form for a technology is required, and the method readily models a multiple input, multiple output firm. This methodology is based on the construction of a "best practice" frontier which is compared to the sample farms to measure efficiency. The best practice frontier is a surface linking the farms which have the highest output for a given a level of inputs.

Using linear programming methods, we constructed a best practice frontier by solving the following problem for k farms:

$$\text{Maximize } \theta$$

s.t.

$$\theta y^0 \leq Yz$$
$$Xz \leq x^0$$
$$z \in R^k_+,$$

where Y is a vector of outputs, X is a vector of inputs, y^0 is a single output for a farm, x^0 is a single input for a farm, and z is parameter reflecting the intensity of use of each input. The intensity parameter z serves to link the observations together which form the best practice frontier. This measure is referred to as overall technical efficiency by Byrnes, et al. (1987).

Data. The data consist of a subset of farms producing corn from the Corn Version of the 1987 FCRS (see description above). From the 1,222 sample farms, 209 fit our criteria of (1) non-irrigated, (2) less than $100 dollars in livestock sales, and (3) in the Corn Belt. These 209 farms represent over 101,000 Corn Belt farms.

In the absence of farm-level data on inputs used for a single commodity enterprise alone, past research has been required to specify a specialized farm and assume that it represents the production of the major commodity. This assumption has never been validated, and in fact, is not necessarily to be expected given that the farm operator is optimizing over a mix of outputs. We specified two models in order to determine if results regarding technical efficiency for the whole farm and the enterprise would be consistent. The models estimated were: (1) a multi-output/multi-input model for the whole corn-producing farm and (2) a single-output/multi-input model for the corn enterprise.

For the multi-input/multi-output specification of production, the output vector is production of corn, soybeans and wheat (in bushels). The input vector is acres harvested, expenditure data on fertilizer and lime, seed, pesticides, equipment fuel, maintenance and depreciation, building and land maintenance and expenses, and labor costs (including unpaid labor expenses based on an average wage rate). Quantities of all inputs would have been preferable to expenditures, but such data were not available. The same specification was duplicated for the corn enterprise alone, that is with the output vector limited to corn production, and the input vector made up of only that portion of expenditures which could be attributed to corn production.

Three size classes were specified based on the economic, or sales, class of the whole farm: $250,000 or more, $40,000 to $249,999, and $39,999 or less. Because of our interest in comparing the whole farm results to the corn enterprise results, size could not be meaningfully specified on a corn acreage basis.

Results. Overall efficiency was calculated for the multi-input/multi-output technology (referred to as whole farm in the tables) and for the corn enterprise by economic size class (table 6). A value of 1.0 for the overall technical efficiency represents a farm on the best practice frontier. It appears that sales classes from $40,000 to $249,999 and $250,000 and greater are more efficient on the average than the smaller farms with sales of $39,999 or less. The same result is true for the corn enterprise alone. Further, in each sales class, the corn enterprise appears to be less technically efficient than the farm as a whole. However, statistical tests to determine if the mean efficiency levels differed between the whole farm and the corn enterprise did not reject the null hypothesis that the difference in the means was zero.

The results of pair-wise comparisons of the means are given in table 7. At the 95% confidence level, the mean overall efficiencies of the whole farm and the corn enterprise alone are the same for large and medium sales classes. However, significant differences were found between the efficiency levels for small and medium farms and small and large farms. This was true for the whole farm and the corn enterprise.

Table 6--Average technical efficiency by sales class

	Sales Class		
	$250,000 or over	$40,000 to $249,999	$39,999 or less
Whole Farm Efficiency	1.14	1.12	1.34
Corn Enterprise Efficiency	1.18	1.17	1.44

Table 7--Comparison of sales class means

	Whole farm	Corn Enterprise
Medium-Large	0.55	0.17
Small-Medium	2.59*	2.27*
Small-Large	2.35*	2.22*

* Significant at the 95% level.

Conclusions

Costs of producing corn vary significantly in the U.S. A major factor affecting the variation is the difference in yields. Given that no major droughts occurred in 1987 and that there are a preponderance of small farms at high levels of cost among all regions, the lower yields of the high-cost group, rather than higher input use per acre, is most likely the major factor in explaining their poorer financial performance in corn production.

Although size was found to be a major factor in cost levels, both the descriptive analysis and the technical efficiency analysis found that the size threshold under which size was important was rather small. Farms with $40,000-$249,999 in sales were found to be as efficient as the large group of corn-producing farms. Similarly, costs per bushel were not significantly different with corn acreages above 100 acres. It is also important to note, however, that farms with corn acreage below 25 acres represent more than a quarter of all corn-producing farms. Like other small farms in the U.S., these farms rely more on their off-farm income than their farm income. These results have reemphasized the importance of jointly accounting for both the farm business and the farm household well-being when analyzing the agricultural sector.

We could not conclude that the farm operation as a whole had a different level of technical efficiency than the corn enterprise. However, this finding is relevant to this sample of corn-producing farms, and future studies of production efficiency should not necessarily

assume that the efficiency levels between a whole farm and its major enterprise will be equal.

References

Ahearn, M., et al. "How Costs of Production Vary", AIB 599, USDA, ERS, May 1990.

Aigner, D., C.A.K. Lovell, and P. Schmidt. "Formulation and Estimation of Stochastic Frontier Production Function Models", J. of Econometrics, Vol. 6, 1977, pp. 21-37.

Byrnes, P., R. Fare, S. Grosskopf, and S. Kraft. "Technical Efficiency and Size: The Case of Illinois Grain Farms", Euro. R. Agr. Eco., Vol. 14, 1987, pp. 367-381.

Fare, R., S. Grosskopf, and C.A.K. Lovell. Measurement of Efficiency of Production. Boston: Kluwer Nijhoff, 1985.

Glaze, D. "A New Approach to Estimating COP Budgets", Agricultural Income and Finance, USDA, ERS. AFO-29, May 1988.

Lau, L.J. and P.A. Yotopoulos. "A Test for Relative Efficiency and An Application to Indian Agriculture", AER, Vol. 61, 1971, pp. 94-109.

APPENDIX: Accounting Concepts of the Corn Cost and Return Estimates

The cost and return estimates in this paper follow the ERS format. That format has been developed over time with input from the National Agricultural Standards Cost of Production Review Board which was established under the 1981 Farm Bill. In addition, ERS formally requested a review of the approach when it was revised in the early 1980's. Commodity groups, land-grant university economists, and individual farmers were asked to participate in the review process.

The ERS format provides gross value of production, variable cash expenses, fixed cash expenses, capital replacement, allocated returns to owned inputs (or opportunity costs), and three measures of residual returns: after cash expenses, after cash expenses and capital replacement, and after economic costs. ERS divides production cash expenses into two broad categories: variable cash expenses and fixed cash expenses. Capital replacement is an economic depreciation--the portion of the value of machinery and equipment that is used up in the production of corn valued at current market values. Economic costs are designed to account for the value of all inputs in production. An imputed cost is calculated for all inputs--whether owned, rented, or financed--in a consistent manner. That is, economic costs represent the production situation as if the operation and landlord fully own the production inputs. Therefore, the economic costs section does not include any interest payments for loans. This full ownership assumption of costs and returns allows comparisons across corn producers without regard to the actual ownership and debt positions of producers.

There are four underlying characteristics of the ERS estimates of crop cost and returns that are incorporated in the corn estimates presented in this paper. The characteristics relate to the treatment of participation in Government programs, the combined operation-landlord focus, the treatment of multi-output production, and the separation of production and marketing costs.

Government programs. ERS estimates exclude the direct effects of Government programs where possible. This is done so that policy makers may be informed as to production costs and returns in the absence of programs. A participant in an income support program is required to set-aside or conserve a portion of his acreage that would have been planted to a particular crop in return for direct Government payments based on production of the crop on his remaining acreage. Participants may also be required to incur costs by maintaining a cover crop or controlling weeds on set-aside acreage. ERS does not include either these costs or direct payments for participating in the Government commodity-based income support programs. If ERS did include the direct effects of Government programs on costs, the greatest effect would generally be on the cost for land. Exclusion of all of the effects from Government programs is not possible, however. For one, participants forgo current income from their acreage that is set-aside, which may lead to increased output on the acreage in following years because the land has been fallow or planted to legumes. For another, both participants and nonparticipants are affected when the supply of a crop is restricted and prices rise. Also, prices of specialized inputs,

particularly cropland, tend to increase as expected income increases either from higher output prices or direct Government commodity program payments.

Combined operation-landlord costs and returns. The estimates of costs and returns are for the farm operation and landlord combined--as if they were one combined business. This means that each line item is for both the farm operation and landlord. The combined operation-landlord account also means that estimates of cash expenses do not include an expense for cash and share rent expenses paid by the farm operation to the landlord. This is because what is a rental expense to the farm business is exactly cancelled as an income to the landlord. Estimates of cash expenses do include an interest expense, however, because generally the interest is paid to those other than the combined operation-landlord entity.

Multi-output. The majority of agricultural commodities are produced by farm businesses producing more than one commodity. This strategy of diversification is carried out by farmers to manage risk and maximize their profits. Where farms produce more than one commodity, inputs that are shared in the production of other commodities must be allocated. Generally, these allocation rules are necessary for machinery-related costs and are based on the acres covered or the hours used for a particular piece of machinery.

Separation of production and marketing costs. In order to separate the costs of production from the costs of marketing, the production costs are to the point of first sale or storage, if the corn is not sold immediately after harvest. Costs of drying and costs of hauling the crop to the elevator or processor are included. Because storage costs are excluded, the corn is valued at its time of harvest.