Staff Papers Series

Staff Paper P88-15 June 1988

ECONOMIES OF SIZE IN U.S. CROP PRODUCTION

by

Stephen C. Cooke and W. Burt Sundquist

Department of Agricultural and Applied Economics

University of Minnesota
Institute of Agriculture, Forestry and Home Economics
St. Paul, Minnesota 55108

Staff Paper P88-15 June 1988

ECONOMIES OF SIZE IN U.S. CROP PRODUCTION

by

Stephen C. Cooke and W. Burt Sundquist

Stephen C. Cooke is an Assistant Professor in the Department of Agricultural Economics, University of Idaho and W. Burt Sundquist is a Professor in the Department of Agricultural and Applied Economics, University of Minnesota.

Economies of Size in U.S. Crop Production

Stephen C. Cooke and W. Burt Sundquist

Introduction

The question of whether or not there are economies of size in U.S. farming is a recurring one which will probably never be answered to everyone's satisfaction. None-the-less, some continuing analysis of the economies-of-size question is important for decision makers, both those engaged in planning, investing and financing for individual farms and those engaged in planning and evaluating future price, income and structure policies for agriculture.

Why is the question of size economies so difficult to resolve? Several kinds of complexities contribute to this problem. First, technologies in farm production are dynamic and everchanging. This makes it difficult to target size-related analyses on the most relevant technologies. Second, the economics of farm production differs by enterprise and/or by combination of enterprises, by location, by differences in the managerial abilities of farmers, for changes in input prices, and so on. Moreover, the survival success rate for different size farm firms is not a good measure of size economies because a variety of other factors are critical to survival. These include, among other things, the risk of unfavorable weather, the timing of entry and/or expansion in farming and the initial capital endowment of the farm firm. For example, size economics aside, a farm business which is heavily indebted at the outset is less likely to survive than one which becomes available to the operator debt free via inheritance (See, for example, Sawani, Finley and Kliebenstein, 1988).

The "economies of size" concept itself has different meaning for different people. But, there is at least some agreement on a general framework for evaluation and a good discussion of this framework is provided by Jensen (1982). First, size economies are most appropriately measured as "costs per unit of output," for example, per hundred weight of milk, per bushel of corn, per ton of sugar beets, etc. This is in contrast to measuring costs on a per acre or per animal unit basis which makes it difficult to compare results between different production regions and different farming systems with their different yields per crop acre and milk production per cow.

Second, in evaluating economies of size in farming, the preferable procedure is to use a "least-cost expansion path" framework for combining farm inputs. This is in contrast to increasing size by combining farm inputs in fixed proportions as is done when measuring the economics of "scale." Since the least cost path for expanding output volume (size) generally involves combining inputs such as labor, machinery, and capital in varying proportions, the economics of scale is not a particularly fruitful concept in assessing size economies in farming.

Third, size economies may arise both through technical (physical input-output) and through pecuniary (financial) relationships. The latter includes both pretax and tax related considerations. Pretax considerations include any size related price effects (generally volume discounts) in the acquisition of production inputs, including capital, or any size related price effects (generally volume premiums) in the sale of farm products. An example of tax related size economies is presented in recent work by Weimer, Hallam and Trede (1988). Thus, in order to understand fully the source of size economies (or diseconomies) it is useful to evaluate technical and pecuniary effects separately.

In the study reported here, we have adhered to the first two of the three considerations mentioned above. But our analysis is limited to technical relationships and to only those pecuniary relationships which are embodied in our data associated with the acquisition of (non-land) capital inputs. We have not attempted to measure other pecuniary relationships.

Study Procedure

Input cost data used in our study comes from a national cost of production sample survey conducted by the U.S. Department of Agriculture for the 1983 crop year, except for cotton for which the survey was for the 1982 crop year (USDA Economic Research Service). These survey data were grouped by sub-state production regions of reasonably homogeneous soils and production practices. And, individual crop enterprises were categorized by size.

Data collected from individual farms included in the USDA survey were used to build the KLEFMA (capital, labor, energy, fertilizer, materials and land) inputs from which to estimate per acre crop production costs for each area/enterprise/size combination. These costs were then divided by per acre yields to obtain costs-per-bushel for corn, soybeans and wheat and costs-per-hundredweight for lint cotton. State-level yields by size of enterprize were obtained from the 1982 Census of Agriculture, scaled to county-level data from the Statistical Reporting Service, USDA and aggregated to appropriate sub-state production regions. Since we had no objective basis for differentiating land input costs between size groups within an area, we have varied only the average cost of land inputs between areas. Costs of data development and analysis limited us to evaluation of the specific crop enterprises and sub-state production regions shown in Table 1 and Figure 1.

Enterprise size is based on planted acres, which includes both owned and rented land. These acreages were then arrayed for each commodity within each area from largest to smallest and three enterprise sizes were designated for study: very large, large and medium (Table 2). The small size category was not included because it included some very small, part-time production units. As a result, we felt any resulting depictions of cost category averages for these small enterprises were not very representative of any individual farming situations. Size categories were determined on the basis of percentiles of the arrayed planted acres and the average enterprise size for each category is shown in Table 3.

Table 1. Geographical Production Regions Included in the Study

Commodity	Selected State	Homogeneous Area	Other
Corn	Illinois	300	
	Indiana	101	
	Iowa	201	
	Nebraska	400	Irrigated
Soybeans	Illinois	300	
	Iowa	201	
	Mississippi	100	
	Ohio	101	
Wheat	Kansas	100	Hard red winter following fallow
	Montana	200	Hard red winter following fallow
	North Dakota	200	Hard red spring continuous
	Washington	400	Soft white winter following fallow
Cotton	Alabama	600	
	California	500	Irrigated
	Mississippi	100	
	Texas	200	Irrigated
	Texas	200	

Selected Homogeneous Soil and Rainfall Areas in Corn, Soybeans, Wheat, and Cotton Production

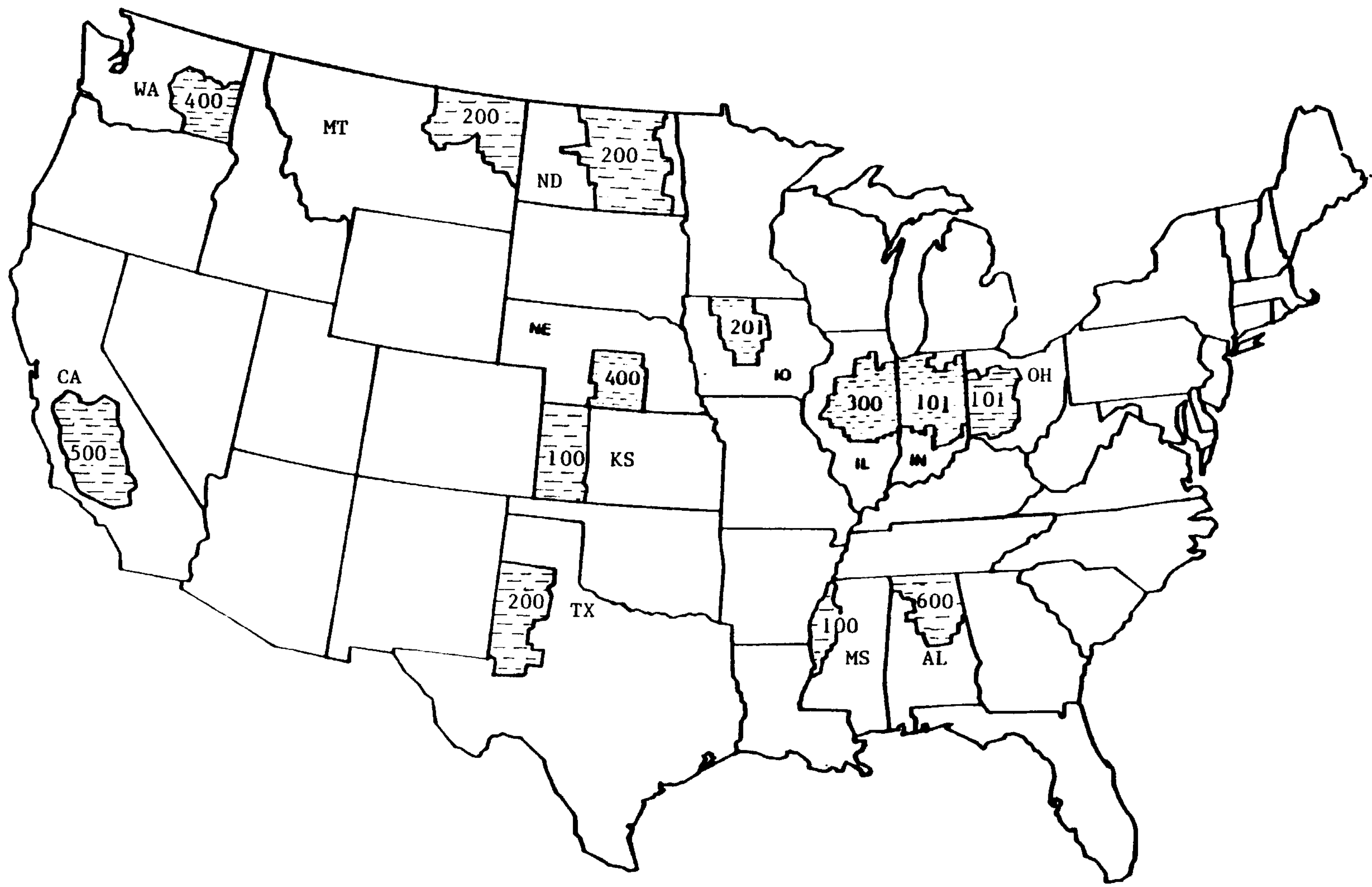

Table 2. Specification of Enterprise Size Categories

Size Category	Percentile of Arrayed Planted Acres
Very large	91-100
Large	71-90
Medium	41-70
Small	0-40 (not included)

Table 3. Average Enterprise Size by Commodity and Production Region

	Corn	Soybeans	Wheat	Cotton	Cotton cont'd
	IL 300	IL 300	KS 100	AL 600	TX 200
			(Planted Acres)		
VL	1113	684	3909	1842	5920
L	355	418	1429	917	1825
M	246	270	774	568	972
Wt. Ave.[1]	520	388	1796	1049	2714
	IN 101	IO 201	MT 200	CA 500[2]	
		(Planted Acres)			
VL	903	707	1577	2833	
L	515	341	619	1432	
M	271	210	421	614	
Wt. Ave.[1]	444	291	1093	2237	

Table 3. Average Enterprise Size by Commodity and Production Region **(continued)**

	Corn	Soybeans	Wheat	Cotton	Cotton cont'd
	IO 201	MS 100	ND 200	MS 100	
		(Planted Acres)			
VL	576	1262	1283	2868	
L	249	894	630	1202	
M	170	795	338	754	
Wt. Ave.[1]	314	1050	672	1686	
	NE 400[2]	OH 101	WA 400	TX 200[2]	
		(Planted Acres)			
VL	1715	897	2388	1707	
L	671	493	1104	929	
M	266	244	753	436	
Wt. Ave.[1]	685	436	1628	971	
Weighted Average[3] - All Production Regions					
		(Planted Acres)			
VL	998	782	2659	2989	
L	403	455	1083	1317	
M	233	299	645	646	
Overall	470	438	1447	1926	

[1]Weights for average enterprise size within an area and across size categories are based on 1982 Census of Agriculture Table 41, "Specified Crops by Harvested Acres" as a ratio of production of this size category to the sum of production across size categories.

[2]Irrigated.

[3]Weights for average enterprise size across areas and within size categories are based on 1981-85 average county level SRS data as a ratio of an areas production to the sum of production across areas.

Economies of Size for Major Crops

Corn:

As indicated in Table 3, average enterprise size for corn ranged between 170 and 271 acres for medium-size enterprises and between 576 and 1715 acres for the very large units. The smallest-size units were located in North Central Iowa and the largest were irrigated corn enterprises in South Central Nebraska.

For each of the four sub-state corn producing areas (see Table 1 and figure 1) significant per-bushel cost economies were realized by very large enterprises as compared to those of medium size. A summary of these size related cost savings effects is shown in Table 4.

Table 4. Sources and Size of Cost Economies in Corn Production, 1983 (Very Large Compared to Medium Size Enterprises)

Area	% per bushel saving from cost reduction	% per bushel savings from increased yield	Total % cost economy per bushel
Illinois 300	10.1	5.2	15.3
Indiana 301	6.0	2.5	8.5
Iowa 201	5.1	4.9	10.0
Nebraska 400	5.8	10.1	15.9
Weighted Average[1]	7.2	5.2	12.4

[1]Weighted by 5 year average production as a portion of U.S. production (1979-83).

Significant savings in factor shares (positive savings for all four situations) came, on average, from reduced capital input shares (6.3%) and reduced labor input shares (1.1%)(See Table 8). Other input cost categories generated small and variable effects on input shares for corn enterprises at each of the four locations. Yield advantages averaged 5.2%

per acre for the very large farms with the largest yield gains coming on the irrigated corn enterprises in South Central Nebraska. When the effects of higher yields and reduced aggregate factor shares are combined for the very large corn enterprises, the average cost economy per bushel amounts to about 12.4 percent ranging from a low of 8.5% (North Central Indiana) to a high of 15.9% (South Central Nebraska, irrigated).

Soybeans:

Average size soybean enterprises ranged from a low of 210 acres for the medium-size enterprise in Iowa Area 201 to a high of 1262 acres for the very-large enterprise in Mississippi Area 100 (Table 3). Although the average-size of enterprise categories were similar in the three Corn-Belt Areas, they were much larger for the Mississippi Delta Area.

Significant savings in factor shares for the very large enterprises (compared to those of medium-size) occurred for two of the input cost categories, capital (2.3%) and materials (2.4%)(Table 8). Per acre labor and energy inputs did not differ significantly by size of enterprise and per acre fertilizer costs were actually slightly higher on the very-large units (1.4%).

Each of the very-large enterprises had small yield advantages over the medium-size units (2.4%)(Table 5). And, all four of the very-large enterprises had per bushel cost-savings via reduced inputs compared to the medium-size units (3.5%). Total cost economies ranged from 2.9 to 11.1% for a weighted average of 5.9%.

Table 5. Sources and Size of Cost Economies in Soybean Production, 1983 (Very Large Compared to Medium Size Enterprises)

Area	% per bushel savings from costs reduction	% per bushel savings from increased yield	Total % cost economy per bushel
Illinois 300	0.8	2.1	2.9
Iowa 201	5.6	1.3	6.9
Mississippi 100	5.7	5.4	11.1
Ohio 101	5.2	3.3	8.5
Weighted Average[1]	3.5	2.4	5.9

[1]Weighted by 5 year average production as a percentage of U.S. (1979-83).

Wheat:

For the wheat areas, only the factor share for capital inputs (among the input cost categories) was consistently lower (2.4)% for the very-large enterprises compared to those of medium-size (See Table 8). As shown in Table 6, aggregate factor share savings for the very large units averaged 4.8%. Yields on two of the three very large wheat enterprises exceeded those for their medium size counterparts while yields on the very-large enterprises in Kansas Area 100 were slightly lower than for the medium size-enterprise. And, although average size of enterprise varied widely between areas, there was also a large acreage differential between size groups for each of the areas (Table 3).

Finally, total cost economies per bushel for the very-large farms ranged from 4.9% for North Dakota Area 200 with the smallest wheat enterprises of any of the study areas, to 14.1% for Montana Area 200 for a weighted average of 7.4%.

Table 6. Sources of Size of Cost Economies in Wheat Production, 1983 (Very Large Compared to Medium Size Enterprises)[1]

Area	% per bushel savings from costs reduction	% per bushel savings from increased yield	Total % cost economy per bushel
Kansas 100	6.9	-0.3	6.6
Montana 200	8.2	5.9	14.1
North Dakota 200	-1.4	6.3	4.9
Weighted Average[2]	4.8	2.6	7.4

[1]Washington Area 400 wheat enterprises were dropped from the cost analysis because of an apparent size-related problem in the sampling procedure within the area. Wheat enterprises become larger as one moves from east to west in the Palouse region of Washington State, but, rainfall decreases and so do yields. This produces a confounding size-yield relationship which biases the estimation of size-cost relationships.

[2]Weighted by 5 year average production as a percentage of U.S. (1979-83).

Cotton:

Table 7 provides indications of the size-factor share and size-yield relationships for very large compared to medium size cotton enterprises. The results are variable between producing areas. Only the very large dryland cotton enterprises in Texas Area 200 realized substantial factor share savings in cost input categories, notably in capital, labor, energy and materials. And, the very large cotton enterprises in the Mississippi Delta actually realized slight factor share increases in capital and materials relative to their medium size counterpart. When combined with yield advantages for three of the five very large cotton enterprises, positive total cost savings (size economies) show up for all but the Mississippi Delta cotton enterprises, although in two areas they are very small.

Table 7. Sources and Size of Cost Economies in Cotton Production, 1982 (Very Large Compared to Medium Size Enterprises)

Area	% per bale savings from costs reduction	% per cwt savings from increased yield	Total % cost economy per cwt
Alabama 600	-2.0	3.3	1.3
California 500[1]	-3.1	7.6	4.5
Mississippi 100	-11.2	2.9	-8.3
Texas 200[1]	3.3	-1.6	1.7
Texas 200	12.2	-2.5	9.6
Weighted Average[2]	-0.8	3.3	2.5

[1]irrigated

[2]Weighted by 5 year average production as a percentage of U.S. (1979-82).

In Summary

In the case of corn and soybean enterprises, size economies existed for all very large enterprises compared to those of medium size. As noted in Tables 4 and 5, aggregate cost savings (economies) per bushel averaged 12.4% for corn and 5.9% for soybeans. Significant factor share savings occurred for capital in the case of corn, and for capital and materials in the case of soybeans (Table 8). In all of the corn-soybean enterprise cases, very large enterprises also enjoyed yield advantages over medium size enterprises. This latter situation was much more pronounced for corn than for soybeans.

In the case of wheat enterprises, significant factor share savings for capital occurred for the Kansas and Montana units whereas yield advantages occurred in Montana and North Dakota (Table 6). On balance, modest cost savings (economies) occurred for all of the very large wheat enterprise units.

In the case of cotton, size-cost relationships were mixed. Even the medium size cotton enterprises average almost 650 acres in size. And, indications are that size economies (cost per hundredweight) have been rather fully exploited on the medium size units for all but the dryland Texas case where the very large cotton enterprise realized significant factor share savings for capital, labor, energy and materials. Not surprisingly, this is the most extensive type of production system of all the cotton enterprise situations studied.

The analyses presented here leave a number of size economy questions unanswered. These analyses do suggest however, that, *ceteris paribus*, based mainly on an assessment of technology already in use, one might reasonably expect some continuing adjustment to larger size of enterprises for corn, soybeans and wheat, to further exploit technology related size economies. But most of the size economies derived from existing technology for cotton may have already been achieved.

Table 8 Weighted Average Shares in Cost Reduction coming from Individual Input Cost Categories (Very Large Compared to Medium Size Enterprises)

	Contribution to Share of Cost Reduction %					
Commodity	Capital	Labor	Energy	Fertilizer	Materials	Totals[1]
Corn	6.3	1.1	0.5	0.3	-1.0	7.2
Soybeans	2.3	0.2	0.0	-1.4	2.4	3.5
Wheat	2.4	0.5	0.1	0.7	1.1	4.8
Cotton	0.2	-0.5	0.6	0.5	-1.6	-0.8

[1]Total cost savings exclusive of yield increases

Cited References

Jensen, H.R. "Another Look at Economies of Size Studies in Farming." Economic Report ER 82-7, University of Minnesota, Department of Agricultural and Applied Economics, St. Paul, Minnesota, August 1982.

Sawani, Mustafa A., Robert M. Finley and James Kliebenstein, "Impact of Farm Indebtedness on Farm Income and Survival." Journal of the American Society of Farm Managers and Rural Appraisers, April, 1988 pp. 24-27.

USDA Economic Research Service. "Firm Enterprise Data System, National Survey of Producers of Agricultural Commodities," conducted by R. Krenz and G. Garst, ERS 1982/83, Stillwater, Oklahoma, unpublished.

USDA, Statistical Reporting Service/National Agricultural Statistical Service. Four County Planted Acres, Yield and Production Data by Commodity, 1972 to 1983," Edited by J. Brueggan, Washington, D.C., available on tape.

U.S. Department of Commerce. 1982 Census of U.S. Agriculture.

Weimar, Mark, Arne Hallam and Larry D. Trede, "Economies of Size, Tax Reform and Profitability of Alternative Midwestern Feedlot Systems." Journal of the American Society of Farm Managers and Rural Appraisers, April, 1988 pp. 11-18.