U.S. Agriculture: Commercial and Large Producer Concentration and Implications for Agribusiness Segments

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Abstract

This study examines rate of concentration of farms and sales for aggregate farm production and crop and livestock activities during the 1982 to 2002 period. Data from the Census of Agriculture are used to calculate Theil's relative entropy measure as an indicator of concentration. Results indicate that Grain segments are lagging behind cotton, potato and hog segments in terms of concentration of total sales, while concentration in the dairy segment appears to be gaining steam. Agribusiness serving less concentrated industry segments should look to the more concentrated segments as leading indicators for effective marketing strategies as concentration increases.

1. Introduction

The structure of production agriculture is rapidly changing due in part to new production and adoption of information technology, government subsidies, and globalization of markets. These events have resulted in a more complicated market environment with agribusiness companies facing larger, more integrated, more specialized, and more demanding agricultural customers. In recent years, agribusiness companies have begun tailoring marketing strategies to different farm segments grouped by farm sales categories. Among these market segments, farms with more than $100,000 in total sales represent a small percentage of farms but account for more than 70% of the market place for agricultural inputs (feed, seed and plants, fertilizer and chemicals). In addition, this market segment accounts for 80% of the livestock income and 87% of crop sales in the U.S. (Table 1).

The overall objective of this study is to provide insight into the significance of different farm size segments in terms of the total number of farms and total agricultural

sales. Moreover, this study will explore differences in the rate of concentration of farms and sales between aggregate and commodity specific agricultural production, and examine the implications of any differences for agribusinesses serving these markets. To reach these objectives, three main hypotheses are tested: (1) concentration of agriculture differs between aggregate and commodity level production, (2) the rate of concentration is increasing over time, and (3) concentration in sales is higher than concentration in farms.

2. Data

This study uses the 1982 through 2002 Census of Agriculture to evaluate changes in the distribution and concentration for the number of farms and total sales in aggregate and commodity specific agricultural production. Aggregate agricultural production represents all agricultural products. Disaggregate agricultural production consists of crop and livestock segments. Crop segments analyzed in this study include corn, soybean, wheat, cotton, and potatoes. Livestock segments include hog, cattle (including cattle and calves), and dairy.

For aggregate agricultural production, data about number of farms and sales were collected from the Agricultural Census tables titled "Economic Class of Farms by Market Value of Agricultural Products Sold and Government Payments" (2002 census) and "Market Value of Agricultural Products Sold and Direct Sales" (census years prior to 2002). For crop segments, data about number of farms and production were gathered from the Agricultural Census table titled "Specified Crops by Area Harvested". For livestock segments, information about number of farms and value of sales were collected

from Agricultural Census tables titled “Hogs and Pigs Inventory and Sales by Number Sold per Farm”, “Cattle and Calves Sales” and “Milk Cow Herd Size by Inventory and Sales”. National marketing year average prices for crops were gathered from the National Agricultural Statistics Service (USDA, NASS) and used to compute sales for each crop.

3. Methodology

The Agricultural Census tables used as the data source for this study classify farms by value of sales (aggregate agricultural production) or size (based on acres in crop segments and number of animals in livestock segments). With the exception of crop segments, sales per farm category were obtained from the census. For crop segments, sales for each farm size category resulted from multiplying crop production by the average crop year marketing price. This is calculated for each of the five census years in the data set. The next sections describe the methodology followed in the distribution and concentration analyses.

3.1 Distribution Analysis

For aggregate and commodity specific agricultural production, farms were grouped into three market segments based on sales. For aggregate agricultural production, sales include sales of all agricultural products. Sales of commodity specific agricultural production, on the other hand, include sales of a specific commodity (except for corn and soybeans where it includes a 50/50 sale of each commodity). Small farms are defined as farms that have below $100,000 in sales; commercial farms, farms that have between

$100,000 and $500,000 in sales; large or "mega" farms, farms that have greater than $500,000 in sales. Then, the percentage of total farms and the percentage of total sales represented by each farm sales category were calculated. This set of information helps to summarize the number of farms and the volume of sales that is represented by each market segment.

3.2 Concentration Analysis

The number of producers per farm category (farm sales categories in aggregate production, farm size categories in commodity specific segments) and the volume of sales represented by this category are used to compute Theil's entropy measure for aggregate agricultural production and each crop and livestock segment[1]. Theil's entropy is a measure of concentration that has been used as an index of industrial concentration in several agricultural activities (poultry processing by Sporleder; hog production by Hubbell and Welsh; hog, dairy and fed-cattle sectors by Herath et al.). However, these studies have focused on geographical concentration of agricultural activities. In this study, we will focus on concentration of farms and sales in aggregate and commodity specific agricultural production.

Given an agricultural activity with n farm categories, let θ_i represent the share of the i^{th} farm category in that activity, absolute entropy $H(\theta)$ is defined as

$$(1) \qquad H(\theta) = \sum_{i=1}^{n} \theta_i \log_2 \theta_i^{-1}$$

where $0 \leq H(\theta) \leq \log_2 n$. If all sales (or farms) of a given agricultural activity are concentrated in the i^{th} farm classification $\theta_i=1$, then $H(\theta)=0$ (maximum degree of concentration). If sales (or farms) of a given agricultural activity are equally distributed

among the n farm classifications, all θ_i will be equal resulting in $H(\theta)= \log_2 n$ (maximum dispersion or minimum degree of concentration). Given that $H(\theta)$ measures the distribution among different farm classifications, $H(\theta)$ will increase as the distribution of farms or sales becomes more equally distributed among farm classifications. For instance, smaller farms once accounted for the majority of farms. However, the difference in the share of farms accounted for different farm size categories has narrowed as the number of smaller farms has decreased. Thus, the decrease in the number of small farms has resulted in a more equal distribution of farms among different farm classifications which leads to an increase in $H(\theta)$.

Relative entropy $R(\theta)$ takes into account differences in the number of farm classifications. Therefore, relative entropy is a measure of concentration that allows for comparison between agricultural activities with a different number of farm classifications. $R(\theta)$ is defined as the ratio between the absolute entropy and the maximum achievable level of dispersion:

$$(2) \qquad R(\theta) = H(\theta) / \log_2 n$$

where $0 \leq R(\theta) \leq 1$. If there is complete concentration of sales (or farms) of a given agricultural activity in a farm classification $R(\theta)=0$. When there is complete dispersion of sales (or farms) between different farm classifications $R(\theta)=1$. $R(\theta)$ will be used in this study to examine the differences in concentration and the rate of change in concentration among aggregate agricultural production and agricultural commodities.

4. Results

The presentation of results is divided in two sections: aggregate and commodity specific distribution analysis, and aggregate and commodity specific concentration analysis. In these sections, results for aggregate agricultural production are followed by commodity specific results.

4.1 Aggregate and Commodity Specific Distribution Analysis

Results indicate that the number of farms and sales represented by small farms decreased over time in aggregate and commodity specific production (Tables 2 and 3). In contrast, the number of farms and sales accounted by "mega" farms increased over time. In all cases, the highest increase in farms and sales in the "mega" farms category occurred during the 1992 to 1997 period. The increase in sales concentration toward larger farms was much more than the increase in concentration of the number of farms.

Commercial and "mega" farms represented a small percentage of farms but accounted for the majority of the aggregate agricultural sales. The percentage of "mega" farms moved from 1.2% of total farms in 1982 to 3.5% of total farms in 2002. However, "mega" farms share of total aggregate sales almost doubled over the 20 year period increasing from 32.5% to 62.7%. In contrast, the percentage of total aggregate sales accounted for small farms and commercial farms decreased by 16.7 and 13.5 percentage points, respectively.

Small and commercial farms accounted for the majority of total grain (corn/soybean and wheat) farms and total grain sales. In addition, there was a fairly modest increase in the number of "mega" grain operations over time. Commercial and

"mega" farms accounted for the majority of cotton sales while the number of cotton farms belonging to the small farms category decreased by 23.2 percentage points over a 20 year period. Since 1992 "mega" potato farms have represented the majority of total potato sales (at least 72% of total sales) but the number of farms belonging to this farm size category remained relatively low (less than 15% of total farms). Moreover, the share of total sales of "mega" potato farms more than doubled over the 20 year period moving from 33.9% to 85.5%.

Commercial and "mega" farms accounted for the majority of total livestock sales in the U.S. However, in 2002 "mega" farms accounted for at least 54.9% of total livestock sales. In addition, sales of "mega" farms presented a substantial increase over time in hog and dairy production. For instance, "mega" hog farms share of total hog sales increased from 10.9% in 1982 to 77% in 2002 with a dramatic increase occurring during the 1992-2002 period. In contrast, there was only a modest increase in the share of total sales of "mega" cattle farms which moved from 45.6% in 1982 to 54.9% in 2002.

In summary, the distribution of farms and sales has changed in agricultural production. Commercial and "mega" farms share of total farms and total sales has increased over time while the number and sales of small farms has declined. However, this change has occurred at different rates of change for different commodity types. For instance, small and commercial farms accounted for the majority of grain farms and sales. In contrast, commercial and "mega" farms have captured the highest share of farms and sales in cotton, potatoes and livestock segments. In addition, the concentration of total sales at the aggregate level shows a substantial increase in concentration over the 20 year period.

4.2 Aggregate and Commodity Specific Concentration Analysis

Relative entropy measures for farms and sales by census year are presented in Tables 4 and 5, respectively. In addition, Figures 1 and 2 provide a visual description of the change in concentration over time. In most cases, $R(\theta)$ for farms in aggregate production were higher than those in commodity specific production indicating that farm numbers are more evenly distributed at the aggregate level. That is, the USDA definition of farm results in a concentration that indicates that production agriculture is not heavily concentrated; there are lots of farms in agriculture. However, relative entropy measures for sales in aggregate production were, in most cases, lower than those in commodity specific production. This result suggests that sales of aggregate production are more heavily weighted towards large sales classes than individual commodities. At the aggregate level, $R(\theta)$ for farms remained relatively constant over the 20-year period while $R(\theta)$ for sales reached the highest level of dispersion in 1987 (72% of the maximum attainable dispersion) and, since then the level of dispersion has declined rapidly indicating rapidly increasing concentration. Plus, the wide discrepancy between the concentration measure for the number of farms and sales highlights the problem with using number of farms as the measure of concentration in the industry.

Relative entropy for the number of farms in individual crop commodity segments, except for cotton, tended to increase indicating that crops have become more evenly distributed among different farm sizes. Increases in relative entropy indicate that the number of crop farms in each size category has become more evenly distributed. This may seem counterintuitive at first, but the increase in relative entropy indicates that number of farms have historically been concentrated in the smaller sales classes. Over

time, the number of farms has declined in smaller sales classes while increasing in larger sales classes. This results in a more even distribution of farms across the size classes, hence, a larger entropy measure. Wheat farms presented the highest dispersion of the number of farms among different farm size classifications with at least 94% of the maximum attainable dispersion in the distribution of farms given the number of farm classifications by size.

$R(\theta)$ for crop sales decreased during the period analyzed, suggesting an increase in the concentration of crop sales into larger farm size classes. However, the rate of change in concentration of sales differed among crops. The distribution of corn sales remained relatively constant (5% change in $R(\theta)$ over the 20 year period) while changes in the distribution of cotton sales and potato sales were substantial; 18% change and 20% change, respectively.

In addition, absolute changes in concentration as measured by $R(\theta)$ of crop sales were higher over the 1992-2002 period than during the 1982-1992 period. Grain sales presented small changes in concentration of sales during these two periods but cotton and potatoes presented significant changes. For instance, absolute changes in concentration of potato sales were 0.04 and 0.12 over the 1982-1992 and 1992-2002 periods, respectively.

The distribution of dairy and cattle farms also became more equally dispersed among different farm sizes (higher relative entropy values) over the 20-year study period. Moreover, the dispersion of hog farms increased during the 1982 to 1992 period but entropy dropped from 0.95 in 1997 to 0.86 in 2002 indicating that the larger size classes are becoming more dominant in the distribution of hog farms. Of the commodities

analyzed, only hog, cotton, and potatoes exhibited the phenomena where relative entropy appeared to have peaked and began to decline in terms of number of farms. This change in direction for number of farms is indicative of the disappearance of small farms in these production sectors. The change in direction suggests that the number of farms in these sectors has moved from being dominated by small farms toward domination in larger farm sizes both in terms of sales and number of farms.

$R(\theta)$ for all livestock sales decreased during the period analyzed indicating that few farm size categories account for a high share of livestock sales (Table 2 and Figure 2). The concentration of hog sales increased by 56% over a 20 year period while the concentration of dairy sales increased by 8%. This reflects the larger increase in the percentage of sales accounted by "mega" hog farms compared to the increase in the share of "mega" dairy farms.

Similar to the crop segment, absolute changes in the concentration of livestock sales were higher over the 1992-2002 period than during the 1982-1992 period. However, these changes were more pronounced on hog sales (absolute change in concentration was 0.07 and 0.41 for the 1982-1992 and 1992-2002 periods, respectively) followed by dairy sales. In contrast, during these two periods, the rate of change in concentration of cattle sales was similar.

5. Conclusions and Implications

This study examined differences in the rate of concentration of farms and sales for aggregate production and crop and livestock activities from 1982 to 2002. Results show differences in the rate of concentration of aggregate and commodity specific production.

For instance, relative entropy results indicate that aggregate level production exhibits a higher level of concentration of sales than most of the individual commodities analyzed. There are several explanations for the discrepancy in concentration between the aggregate and commodity specific segments. One reason is that many farms are diversified on their production activities resulting in higher total sales despite not being "mega" in any one commodity. Another explanation is that the individual commmodity analysis did not include some higher value agricultural segments that are expected to be highly concentrated such as poultry and fruits and vegetables.

The share of small farms in number of total farms and total sales has decreased over time, particularly in cotton, hog and dairy production. However, small and commercial farms still dominate total grain farms and grain sales in the U.S. On the other hand, cotton sales are dominated by commercial and "mega" farms, and a small but increasing number of "mega" farms account for the majority of potato and livestock sales.

Relative entropy measures for sales in the crop segment ranged between 0.61 and 0.84 and in the livestock segment between 0.38 and 0.87. The lower range of values of the relative entropy measure in the livestock segment suggests that the degree of concentration of sales in a small number of "mega" farms is higher in livestock segments than in crop segments. For most segments, the relative entropy measure of sales is decreasing over time, with cotton, potatoes and livestock seeing the most rapid decrease in recent periods. Among crop and livestock segments, hog production presents the most rapid decrease in the relative entropy measure of sales during the period analyzed (56% decrease), followed by cotton and potato segments (18% and 20% decrease,

respectively). These results suggest that grain segments are lagging behind cotton, potato and hog segments in terms of concentration of total sales. As such, the cotton and potato market may be a leading indicator for what may happen in grain markets in the future.

Absolute changes in the concentration of crop and livestock sales are higher over the 1992-2002 period than during the 1982-1992 period. However, these changes are more substantial in cotton, potato, hog and dairy sales. The key question is whether the accelerated pace of concentration in these segments is going to come to other segments. Is there a point where grain sales begin to consolidate at the pace that cotton, potato and hog sales have experienced? Or, are these commodities destined to concentrate at a slower pace?

Structural change is not new in agriculture. However, the rate with which production agriculture is consolidating does appear to be increasing particularly in cotton, potatoes and livestock segments. Agribusiness companies need to recognize that while numbers of customers may not change dramatically over a period of time, the consolidation of land and animals into the control of a smaller set of customers increases rapidly. For those agribusinesses that produce products that rely on acres or head of livestock, this small set of larger producers is likely to represent an increasing portion of their business volume. This concentration has significant implications for marketing and sales strategies; particularly if this smaller segment of customers has a much different value proposition than the mass number of producers that represent a shrinking amount of the agribusiness company's volume.

Endnotes

[1] Changes in concentration due to variations in the number of farm classifications among census years are avoided by using the same number of farm categories throughout the period analyzed. For the aggregate production, these categories are the farm sales categories reported in all five censuses. For crop segments, these categories are those farm size categories reported for corn, soybean, wheat and cotton during the 1982 Census of Agriculture. Farm categories are aggregated for potatoes in years where more classes are reported in the census in order to keep the number of categories constant and equal among crops. In livestock segments, each livestock activity has a different number of farm size categories. These categories are those reported for each livestock activity during the 1982 Census of Agriculture. Farm categories are aggregated in years where more classes are reported in the census to keep the number of classes constant.

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Table 1. Farms by gross value of sales in 2003[a]

	$500,000 or more	$100,000 to $499,999	Less than $100,000
Farms	3%	12%	85%
Livestock income	52%	28%	20%
Crop sales	55%	34%	11%
Variable expenses			
Feed	58%	20%	22%
Seed and plants	48%	37%	16%
Fertilizer and chemicals	40%	41%	19%

[a] Percentages may not add up to 100% due to rounding error.
Source: Computations from USDA, ERS.

Table 2. Distribution of crop farms and crop sales between farm sales categories by census year[a]

	1982		1987		1992		1997		2002	
	% Farms	% Sales	% Farms	% Sales	% Farms	% Sales	% Farms	% Sales	% Farms	% Sales
Aggregate										
Small farms	0.865	0.274	0.858	0.237	0.827	0.174	0.819	0.126	0.848	0.107
Commercial farms	0.123	0.401	0.126	0.382	0.149	0.367	0.145	0.308	0.117	0.266
Large or "mega" farms	0.012	0.325	0.015	0.382	0.024	0.459	0.036	0.566	0.035	0.627
Corn										
Small farms	0.905	0.531	0.910	0.557	0.834	0.394	0.804	0.333	0.757	0.266
Commercial farms	0.091	0.399	0.087	0.394	0.158	0.511	0.181	0.521	0.217	0.525
Large or "mega" farms	0.004	0.070	0.003	0.049	0.009	0.095	0.015	0.146	0.026	0.209
Soybeans										
Small farms	0.872	0.515	0.867	0.521	0.825	0.424	0.771	0.336	0.716	0.264
Commercial farms	0.128	0.485	0.133	0.479	0.164	0.474	0.209	0.511	0.252	0.525
Large or "mega" farms	0.000	0.000	0.000	0.000	0.010	0.101	0.020	0.152	0.033	0.212
Wheat										
Small farms	0.978	0.781	0.982	0.822	0.963	0.723	0.945	0.645	0.936	0.625
Commercial farms	0.022	0.219	0.018	0.178	0.037	0.277	0.055	0.355	0.064	0.375
Cotton										
Small farms	0.690	0.206	0.700	0.245	0.601	0.152	0.513	0.116	0.458	0.089
Commercial farms	0.273	0.466	0.275	0.524	0.343	0.510	0.388	0.477	0.402	0.420
Large or "mega" farms	0.037	0.328	0.025	0.231	0.056	0.337	0.099	0.407	0.139	0.491
Potatoes										
Small farms	0.866	0.139	0.755	0.107	0.687	0.029	0.666	0.020	0.707	0.012
Commercial farms	0.117	0.522	0.209	0.503	0.201	0.249	0.201	0.196	0.152	0.133
Large or "mega" farms	0.017	0.339	0.036	0.390	0.112	0.722	0.134	0.784	0.141	0.855

[a] Percentages may not add up to 100% due to rounding error.

Table 3. Distribution of livestock farms and livestock sales between farm sales categories by census year[a]

	1982		1987		1992		1997		2002	
	% Farms	% Sales	% Farms	% Sales	% Farms	% Sales	% Farms	% Sales	% Farms	% Sales
Aggregate										
Small farms	0.865	0.274	0.858	0.237	0.827	0.174	0.819	0.126	0.848	0.107
Commercial farms	0.123	0.401	0.126	0.382	0.149	0.367	0.145	0.308	0.117	0.266
Large or "mega" farms	0.012	0.325	0.015	0.382	0.024	0.459	0.036	0.566	0.035	0.627
Hogs										
Small farms	0.931	0.520	0.900	0.427	0.853	0.313	0.787	0.127	0.763	0.052
Commercial farms	0.065	0.371	0.093	0.412	0.133	0.425	0.163	0.277	0.149	0.179
Large or "mega" farms	0.004	0.109	0.007	0.161	0.014	0.262	0.050	0.596	0.088	0.770
Dairy										
Small farms	0.900	0.595	0.567	0.220	0.523	0.175	0.449	0.116	0.422	0.080
Commercial farms	0.094	0.300	0.425	0.642	0.429	0.483	0.477	0.411	0.479	0.322
Large or "mega" farms	0.005	0.105	0.008	0.137	0.049	0.342	0.074	0.473	0.098	0.599
Cattle										
Small farms	0.964	0.338	0.960	0.327	0.957	0.298	0.956	0.276	0.944	0.252
Commercial farms	0.032	0.206	0.035	0.201	0.037	0.193	0.038	0.177	0.049	0.199
Large or "mega" farms	0.004	0.456	0.005	0.472	0.006	0.509	0.006	0.547	0.008	0.549

[a] Percentages may not add up to 100% due to rounding error.

Table 4. Relative entropy measures for farms by census years

						Absolute Change	
	1982	1987	1992	1997	2002	1982-1992	1992-2002
Aggregate	0.95	0.95	0.96	0.97	0.95	0.01	0.01
Corn	0.87	0.87	0.91	0.92	0.94	0.04	0.03
Soybeans	0.88	0.88	0.90	0.91	0.92	0.01	0.03
Wheat	0.94	0.94	0.96	0.97	0.97	0.02	0.01
Cotton	0.93	0.92	0.93	0.92	0.91	0.01	0.02
Potatoes	0.49	0.70	0.66	0.68	0.61	0.16	0.05
Hogs	0.87	0.90	0.93	0.95	0.86	0.06	0.07
Dairy	0.74	0.74	0.78	0.79	0.85	0.04	0.07
Cattle	0.71	0.73	0.73	0.73	0.76	0.02	0.02

Table 5. Relative entropy measures for sales by census years

						Absolute Change	
	1982	1987	1992	1997	2002	1982-1992	1992-2002
Aggregate	0.49	0.72	0.66	0.58	0.53	0.17	0.13
Corn	0.82	0.82	0.80	0.80	0.78	0.02	0.02
Soybeans	0.83	0.81	0.81	0.80	0.78	0.02	0.03
Wheat	0.84	0.85	0.81	0.78	0.77	0.03	0.04
Cotton	0.74	0.77	0.71	0.66	0.61	0.04	0.10
Potatoes	0.82	0.80	0.78	0.74	0.66	0.04	0.12
Hogs	0.86	0.84	0.79	0.57	0.38	0.07	0.41
Dairy	0.83	0.83	0.84	0.82	0.76	0.02	0.09
Cattle	0.87	0.86	0.83	0.79	0.79	0.04	0.04

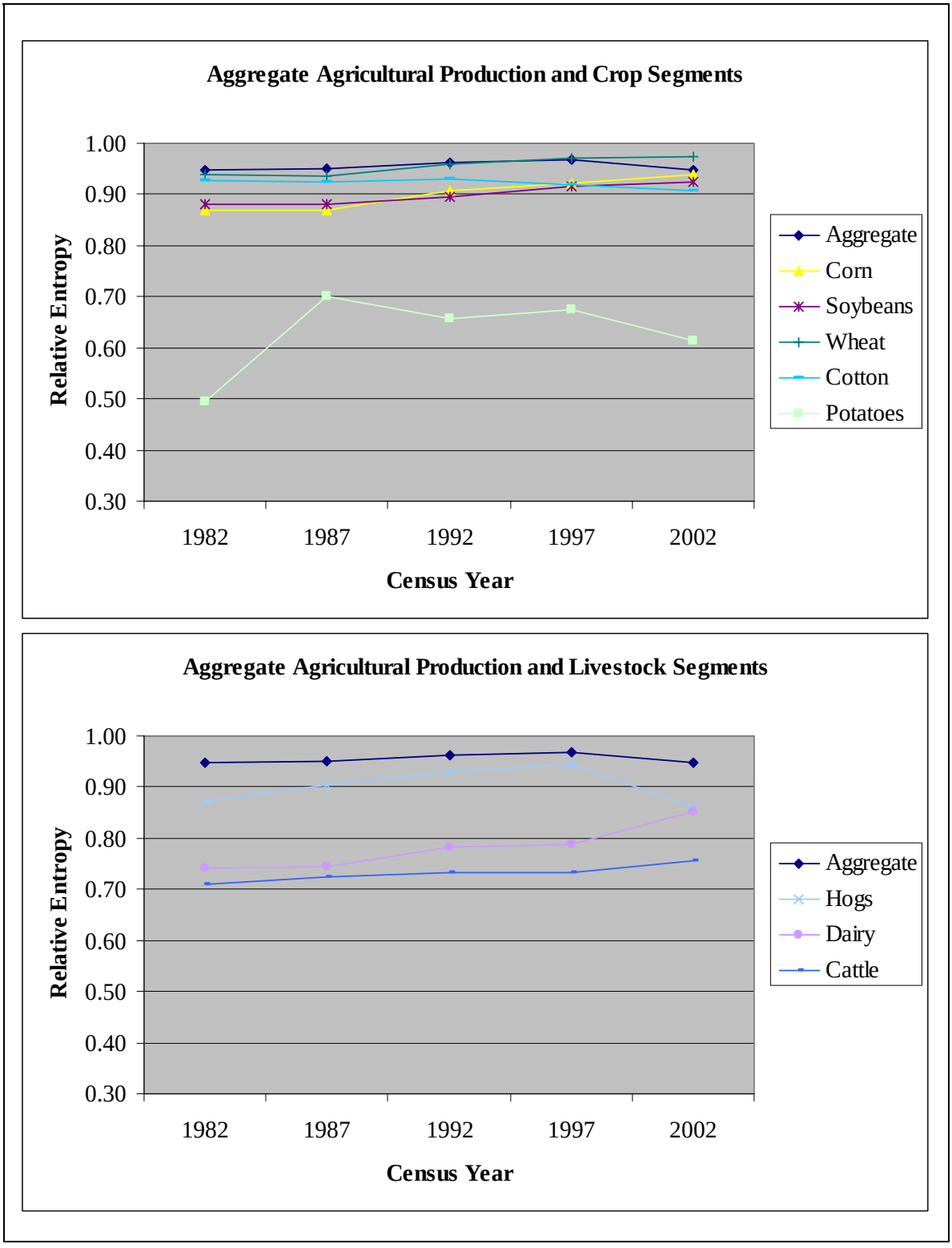

Figure 1. Concentration measures for farms over the 1982 to 2002 period

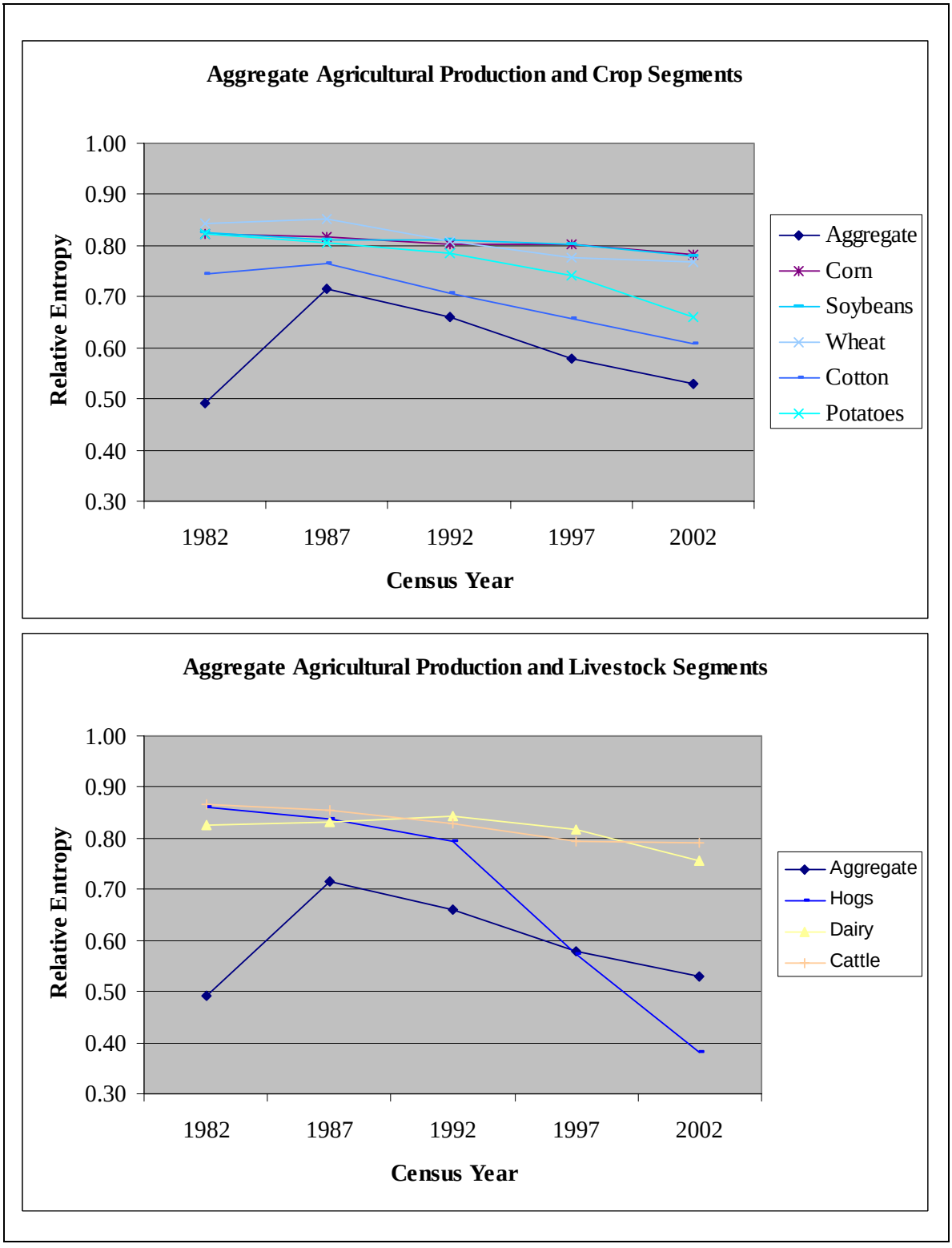

Figure 2. Concentration measures for sales over the 1982 to 2002 period