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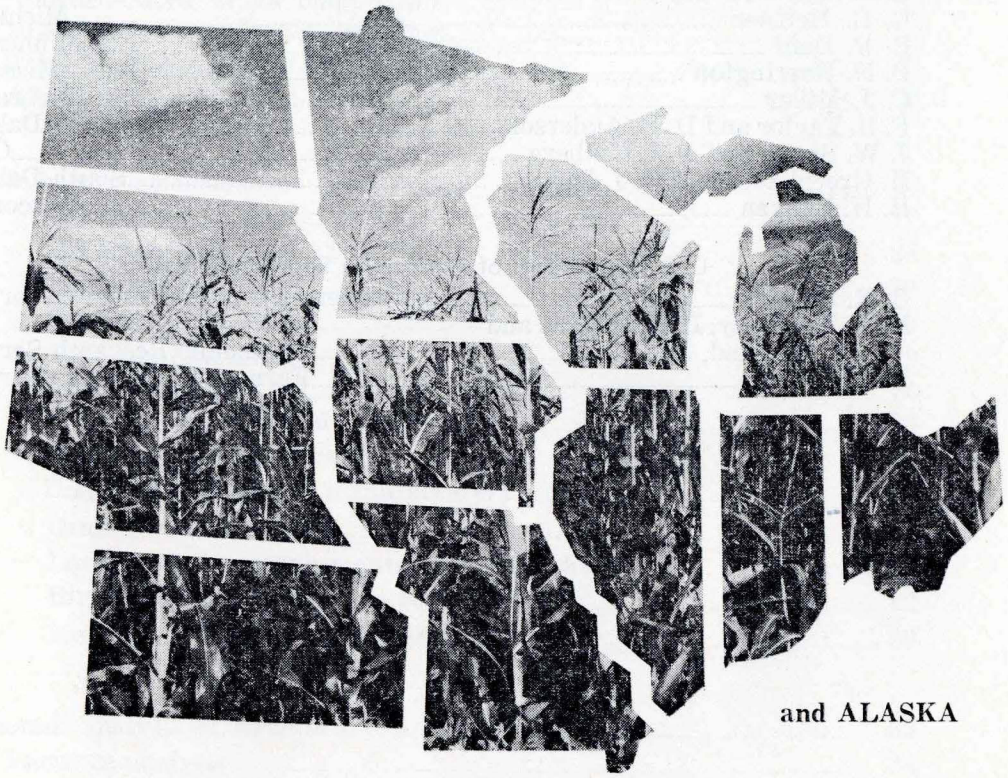
FIRM GROWTH PROCESSES AND STRUCTURAL CHANGES IN THE GRAIN INDUSTRIES OF THE NORTH CENTRAL REGION



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AGRICULTURE AND HOME ECONOMICS EXPERIMENT STATION
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Technical Committee for NCM-30 Grain Marketing Institutions and the Structure of Grain Markets

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Summary and Conclusions

The objective of this study was to describe and analyze the nature, direction and magnitude of the structural changes that occurred in the grain-marketing and processing industries of the North Central Region in the 1954-1960 period. Observed structural changes were related to the growth processes of individual firms and evaluated by stochastic processes and regression analysis to determine their implications for future structural adjustments in the regional grain industries.

Over-all, these firms tended to:

1. show a high degree of size mobility,
2. increase the importance of multi-plant operations,
3. decrease concentration slightly,
4. increase specialization to a small extent and
5. maintain a high merger rate.

However, subgroups of firms exhibited the following unique adjustments:

1. The largest firms merged with small firms at a rate that, in itself, would have increased concentration;
2. the largest firms tended to specialize;
3. medium-sized firms tended to diversify;
4. small firms accounted for a high proportion of entry and exit into the industries and were highly mobile within size classes;
5. grain processors tended to specialize, although diversified firms continued to control the bulk of grain processed; and
6. grain-merchandising firms tended to diversify.

Detailed presentation of the basis of each of these general conclusions is given in this report. This study also suggests the desirability of using a combination of various tools and techniques to analyze structural change. Simplistic measurements of concentration ratios or changes in market shares frequently overlook significant changes in the composition and over-all size distribution of firms in the industry. The degree of specialization or diversification in a set of related activities is also emphasized.

The emphasis in this study is on description, measurement and explanation. No attempt is made to appraise the normative implications of the observed changes. Explanation was sought inductively through measurement of average and general tendencies and through the use of theoretical models and concepts applied to this industry. Additional explanation is possible and desirable through more intensive study of growth forces internal and external to the industry. Those analyses were included in the NCM-30 regional research project of which this study was a part.

Firm Growth Processes and Structural Changes in the Grain Industries of the North Central Region

by Lehman B. Fletcher and Donald D. Kramer[1]

Growth is an important objective of the modern business enterprise. It is the means by which firms adjust to the environmental factors affecting their industries and individual operations. In turn, changes in firm size and organization, including entry and exit, determine the structural characteristics of a given industry at a given point in time. Although industry structure can be described statically, obviously growth processes leading to structural changes must be analyzed over time. This report uses several static and dynamic models to describe and analyze the process of structural change in the grain industries of the North Central Region.

Objectives

The general objective of this study was to determine the direction and magnitude of the major changes in firm organization and growth processes associated with the structural changes in the North Central Region (NCR) grain-marketing industry. More specifically, for each major type of firm ownership, each subindustry and the entire NCR grain industry, attempts were made to: (a) measure the changes in firm size and industry concentration, (b) classify these changes into basic components of specialization and diversification and (c) assess the relative importance of these components.

Method and Procedure

This research was conducted under the auspices of the technical committee of the regional research project in grain marketing of the North Central Region (NCM-30). Previous projects conducted by this committee, NCM-10 and NCM-19, provided the starting point for research for the NCM-30 regional project. Contributions to the project were also made by the Marketing Economics Division, United States Department of Agriculture.

The importance of the North Central Regional grain-marketing industries in the United States is illustrated by the fact that, in both 1954 and 1959, about two-thirds of national grain production was accounted for by states in the region (43, p. 2). Individual grain produced in the region includes corn, soybeans, wheat, oats, barley and sorghum. The following 11 states were included in this project:

Illinois	Minnesota	Ohio
Indiana	Missouri	South Dakota
Iowa	Nebraska	Wisconsin
Kansas	North Dakota	

Surveys were taken of NCR grain-marketing plants for 1954 and 1960. Volume data were obtained in terms of bushels of grain. Merchandising volume indicates both domestic and export volumes. For processors, volume data represented grain volume input used in the processing activities. Plants were included if they met the following criteria:

Grain Merchandisers — Plants reselling grain that receive less than 50 percent of their grain direct from farmers. Plants qualifying under this definition were primarily subterminal and terminal elevators.

Grain Processors — Plants with a minimum daily processing capacity of not less than 50 tons **and** who dispose of at least 50 percent of their processed products through wholesale channels.

A total of 578 and 598 plants qualified in 1954 and 1960, respectively. Plants were classified into three categories: (a) plants doing grain merchandising only, (b) plants doing grain processing only and (c) plants doing both. Processing plants were further classified on the basis of processing activity (table 1). Firms were classified as single- or multi-plant operations and also as to cooperative or noncooperative ownership. Multi-plant firm classification required at least two qualifying plants in the region. Noncooperative firms include single proprietorships, partnerships and corporations.

INDUSTRY ORGANIZATION AND STRUCTURAL CHANGES

Firm Ownership, Organization and Size

Analysis of various regional subindustries was undertaken to determine structural changes in important subgroups of firms in the NCR grain in-

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dustry. Changes in the aggregate distribution of plants, firms and volumes between 1954 and 1960 reflect important organizational developments. Analysis of industry groups was carried out by major type of firm ownership and firm organization.

Table 1. Merchandising and processing industry codes for North Central Regional plants and firms.

Code	Industry or industry combinations
00	Grain merchandising only
01	Feed manufacturing
02	Flour milling
03	Oilseed processing
04	Dry milling for food
07	Alcohol manufacturing or distilling
12	Wet corn milling
13	Malting or brewing
01-04	Feed manufacturing and dry milling for food
01-13	Feed manufacturing and malting
02-01	Flour milling and feed manufacturing
02-04	Flour milling and dry milling for food
02-13	Flour milling and malting
02-03-04	Flour milling, oilseed processing and dry milling for food
01-02-04	Feed manufacturing, flour milling and dry milling for food
03-01	Oilseed processing and feed manufacturing
03-04	Oilseed processing and dry milling for food
03-12	Oilseed processing and wet corn milling
12-13	Wet corn milling and malting

Table 2 shows the distribution of plants, firms and volume between cooperative and noncooperative firms in the regional grain industry and the changes from 1954 to 1960. The cooperative form of firm ownership is much less important than the noncooperative, but the cooperative form has become relatively more important since 1954.

The number of cooperative single- and multi-plant firms increased from 1954 to 1960 (table 3). Single-plant firms became relatively more important, especially in terms of volume.

A comparison of table 3 with table 4 indicates that, for noncooperatives, multi-plant firms are more important in terms of volume than are coops. Increases in plants per firm and the number of multi-plant firms caused multi-plant operations to become increasingly important in 1960. The relative increase in multi-plant volume was mainly caused by the increased number of multi-plant firms and not by further growth of the large, multi-plant firms.

Cooperative single-plant firms

The 1954 and 1960 distributions of single-plant cooperatives are given in table 5. This table shows the percentage distributions of firms and volumes by industry. These percentage comparisons should

Table 2. Cooperative and noncooperative firms: distribution of plants, firms and volume, 1954 and 1960.

	1954				1960			
	Cooperatives		Noncooperatives		Cooperatives		Noncooperatives	
Item	number	percentage	number	percentage	number	percentage	number	percentage
Plants	48	8.3	530	91.7	59	9.9	539	90.1
Firms	28	8.2	315	91.8	35	11.6	266	88.4
Volume (000 bu.)	156,970	8.4	1,720,297	92.6	274,747	12.2	1,976,583	87.8

Table 3. Cooperatives: distribution of plants, firms and volumes between single- and multi-plant firms, 1954 and 1960.

	1954				1960			
	Single-plant		Multi-plant		Single-plant		Multi-plant	
Item	number	percentage	number	percentage	number	percentage	number	percentage
Plants	18	37.5	30	62.5	24	40.7	35	59.3
Firms	18	64.3	10	35.7	24	68.6	11	31.4
Volume (000 bu.)	51,290	32.7	105,680	67.3	138,042	50.2	136,705	49.8

Table 4. Noncooperatives: distribution of plants, firms and volumes between single- and multi-plant firms, 1954 and 1960.

	1954				1960			
	Single-plant		Multi-plant		Single-plant		Multi-plant	
Item	number	percentage	number	percentage	number	percentage	number	percentage
Plants	252	47.5	278	52.5	194	36.0	345	64.0
Firms	252	80.0	63	20.0	194	72.9	72	27.1
Volume (000 bu.)	435,041	25.3	1,285,256	74.7	405,551	20.5	1,571,032	79.5

be considered in light of a volume increase for this group of firms of 250 percent. Grain merchandising is most important on a volume basis and gained in importance during this period. This group of firms has only a limited involvement in processing, although the number of firms manufacturing feed increased dramatically between 1954 and 1960.

Further analyses were conducted in which cooperative single-plant firms were individually traced and classified by net changes in number of merchandising and processing activities. This process involved tabulating individual firm changes and neglected the relative sizes of firms. The hypothesis was that the mean of the differences of number of per-firm activity (industry) additions was zero. Snedecor's (41, p. 49) t-tests of differences were used. The mean difference, 0.4, was significant at the 0.01 probability level. On the average, the mix of activities per firm was more heterogeneous in 1960 for the single-plant cooperative firms.

An additional t-test was conducted on differences between 1960 and 1954 firm product-diver-

Table 5. Single-plant cooperatives: Distribution by industry and volume, 1954 and 1960

Item	00	01	03	03-01	Total processing
			(percentage of region)		
Single-plant cooperative processors					
Firms					
1954	38.9	16.7	22.2	11.1	50.0
1960	29.2	25.0	8.3	4.2	37.5
Volume					
1954	55.2	10.8	7.9	21.9	40.6
1960	81.6	6.2	1.6	1.9	9.7
Single-plant combined merchandisers and processors					
Firms					
1954	....	....	5.5	5.6	11.1
1960	....	16.6	4.2	12.5	33.3
Volume					
1954	....	....	1.4	2.8	4.2
1960	....	2.6	2.7	3.4	8.7

Table 6. Multi-plant cooperatives: distribution by industry and volume, 1954 and 1960.

Item	00	01	02	03	Total processing
			(percentage of region)		
Multi-plant cooperative processors					
Plants					
1954	66.7	16.7	3.3	....	20.0
1960	57.1	25.7	2.9	5.7	34.3
Firms					
1954	50.0	25.0	6.2	....	31.2
1960	38.9	33.3	5.6	11.1	50.0
Volume					
1954	84.9	1.2	1.6	....	2.8
1960	69.5	11.9	1.5	15.7	29.1
Multi-plant combined merchandiser and processors					
Plants					
1954	....	10.0	....	3.3	13.3
1960	....	5.7	....	2.9	8.6
Firms					
1954	....	12.5	....	6.3	18.8
1960	....	5.6	....	5.5	11.1
Volume					
1954	....	11.2	....	1.1	12.3
1960	....	0.3	....	1.1	1.4

sification ratios to measure the significance of the change in product mix. The firm diversification ratios were defined as the ratio of volume in the nonprimary activities divided by total firm volume. For survivors, the mean of the differences was not significantly different from zero. (For this and subsequent sections, survivors mean firms included in the survey in both time periods. Births and deaths mean firms included only in 1960 or 1954, respectively.) The inclusion of births resulted in a significant difference at the 0.1 level. Thus, new firms were more diversified than the 1954 average firm.

Cooperative multi-plant firms

Table 6 illustrates that multi-plant coops are shifting importance away from merchandising and into processing. Total volume for this group increased by about 30 percent. Diversification, in contrast to single-plant cooperatives, became less important in terms of less concentration in heterogeneous industry combinations. The number of multi-plant cooperative firms was too small for t-tests. Tabulation of the data indicated no significant change in the average number of firm activities and a slight increase in the average diversification of activities by these firms.

Table 7. Cooperatives: distribution of plants and volumes between single- and multi-plant firms, 1954 and 1960.

Item	00	01	02	03	03-01	Total
			(percentage)			
Single-plant cooperatives						
Plants						
1954	14.6	6.3	....	10.4	6.2	37.5
1960	11.9	16.9	....	5.1	6.8	40.7
Firms						
1954	20.6	8.8	....	14.7	8.8	52.9
1960	16.7	23.8	....	7.1	9.5	57.1
Volume						
1954	18.0	3.5	....	3.1	8.1	32.7
1960	41.0	4.5	....	2.1	2.6	50.2
Multi-plant cooperatives						
Plants						
1954	41.6	16.7	2.1	2.1	....	62.5
1960	33.9	18.6	1.7	5.1	....	59.3
Firms						
1954	23.5	17.6	3.0	3.0	....	47.1
1960	16.7	16.7	2.4	7.1	...	42.9
Volume						
1954	57.2	8.3	1.1	0.7	....	67.3
1960	34.6	6.1	0.7	8.4	....	49.8

Table 8. Noncooperative single-plant firms: distribution by industry of plants, firms and volumes, 1954 and 1960.

Industry	Processing firms				Combination merchandising and processing firms			
	Firms 1954	Vol. 1954	Firms 1960	Vol. 1960	Firms 1954	Vol. 1954	Firms 1960	Vol. 1960
				(percentage)				
00	19.4	24.0	29.4	34.7	....	....	....	....
01	15.8	5.0	14.5	5.4	15.4	5.4	15.0	4.4
02	11.5	12.7	10.3	9.7	3.6	5.3	3.6	4.3
03	4.4	4.8	3.1	3.6	5.2	6.1	2.6	4.1
04	2.0	5.8	2.6	6.6	0.4	0.1	....	....
07	2.4	1.9	1.5	1.8	0.4	0.6	....	....
12	2.4	11.9	2.6	11.7	....	....	....	....
13	4.7	3.9	5.2	3.7	....	....	1.0	3.6
01-04	0.8	0.1	0.5	0.1	0.8	0.2	1.5	1.0
01-13	0.4	0.3	....	....	....	....	....	....
02-01	2.0	1.7	1.0	0.2	3.6	1.1	3.1	1.1
02-04	1.2	1.7	0.5	0.1	....	....	....	....
02-13	....	....	....	....	....	....	....	....
02-03-04	....	....	....	....	0.4	1.0	....	....
01-02-04	....	....	....	....	....	....	....	....
03-01	0.4	0.1	0.5	0.1	1.6	0.9	0.5	0.9
03-04	0.4	2.9	....	....	0.4	0.1	0.5	0.4
03-12	....	....	....	....	....	....	....	....
12-13	0.4	2.4	0.5	2.6	....	....	....	....
Total processing firms	48.8	55.2	42.8	45.6	31.8	20.8	27.8	19.7

Total cooperative firms

The relative importance of single- and multi-plant cooperative firms for the various grain industries is illustrated by table 7. By comparing the relative figures for each industry, the changes in importance of multi- versus single-plant operations are indicated. Further, horizontal comparisons assess the importance of each type of operation (industry) within the cooperative group. The existence of multi-plant economies is not tested directly, but if they exist, they were not exploited by cooperative firms between 1954 and 1960. Diversification became more important for cooperatives both because cooperative firms added new activities and because they increased volumes in existing diversified activities.

Noncooperative single-plant firms

Table 8 indicates the wide diversity of industries in the noncooperative single-plant firm distribution.[2] In contrast to cooperatives, grain merchandising was of lesser relative importance, but increased in importance in the 1954-60 period. In terms of concentration by firm in more heterogeneous industry combinations, diversification for this group was of lesser importance in 1960.

Noncooperative multi-plant firms

Noncooperative multi-plant firms showed an increase in the importance of merchandising activities (table 9). Diversification, in terms of concentration in more heterogeneous operations, was unimportant in the aggregate, although both increasing and decreasing importance of diversification was observed for different component industries. Again, a t-test was used to show that the mean of the increase in firm activities, 0.19, was significant at the 0.01 level. But the average increase in per-firm volume diversification was not significantly different from zero. The inclusion of births in the product-mix values yielded a significant mean increase. Thus, births were more diversified than the 1954 noncooperative multi-plant average.

Total noncooperative firms

Table 10 illustrates the growing importance of multi-plant firms. As previously indicated, both vertical and horizontal comparisons can be made from the table. Both increases and decreases are observed for changes in importance of multi-plant firms for component industries. The more important industries (in terms of volume) had more pronounced increases in multi-plant organization. Obviously, these increases in importance developed because percentage increases in multi-plant firms, plants and volume were greater in the particular industry than for the total. In table 10, the total row summarizes these changes, and as illustrated, multi-plant firms are becoming more important.

All firms

Table 11 permits static summary comparisons of the changing importance of multi-plant firms. In summary, single-plant firms accounted for

[2] In table 8 for 1954, grain merchandising (00) only makes up 24 percent of the volume while processing only makes up 55.2 percent of the volume and firms that do both merchandising and processing make up 20.8 percent of the total volume. Similarly for 1960 the percentage of the volume attributable to each is: grain merchandising only 34.7 percent, processing only 45.6 percent and firms combining both merchandising and processing 19.7 percent.

Table 9. Noncooperative multi-plant firms: distribution by industry of plants, firms and volumes, 1954 and 1960.

Industry	Processing firms						Combination merchandising and processing firms					
	Plants		Firms		Volume		Plants		Firms		Volume	
	'54	'60	'54	'60	'54	'60	'54	'60	'54	'60	'54	'60
	(percentage)											
00	36.7	37.7	24.2	24.2	37.6	41.6	....	....	....	....	....	....
01	11.1	14.8	10.9	14.4	3.6	2.4	4.7	3.8	8.6	6.9	1.6	1.3
02	15.1	13.6	10.9	9.4	11.5	10.6	5.8	4.3	5.5	5.7	7.3	7.2
03	9.0	7.8	10.2	10.0	9.2	9.1	1.1	1.4	2.3	2.5	2.9	3.3
04	2.1	1.7	3.9	3.7	1.3	0.6	....	0.6	....	1.2	....	1.0
07	1.1	1.4	1.6	1.9	0.4	0.6	....	....	....	....	....	....
12	1.1	1.2	0.8	1.2	4.6	4.8	....	....	....	....	....	....
13	1.4	1.4	3.1	1.2	0.7	0.7	0.7	0.6	1.5	1.2	1.2	0.8
01-04	1.8	0.6	2.3	1.2	3.6	1.3	0.3	1.4	0.8	3.2	0.3	1.4
01-13	....	....	....	....	....	....	....	....	....	....	....	....
02-01	0.4	0.6	0.8	1.2	0.1	0.4	0.3	0.6	0.8	1.2	0.1	0.4
02-04	0.4	0.6	0.8	1.2	0.3	0.5	0.7	0.3	1.6	0.6	1.2	0.4
02-13	....	....	....	....	....	....	0.4	....	0.8	....	0.6	....
02-03-04	0.4	....	0.8	....	0.1	....	....	0.3	....	0.6	....	0.5
01-02-04	....	0.3	....	0.6	....	0.1	0.4	0.3	0.8	0.6	0.6	0.5
03-01	2.1	0.9	2.3	1.2	2.4	1.3	2.5	2.9	3.9	3.1	5.8	5.1
03-04	....	0.3	....	0.6	....	1.2	....	....	....	....	....	....
03-12	....	....	....	....	....	....	0.4	0.6	0.8	1.2	3.1	2.9
12-13	....	....	....	....	....	....	....	....	....	....	....	....
Total processing firms	46.0	45.2	48.4	47.8	37.8	33.6	17.3	17.1	27.4	28.0	24.6	24.8

Table 10. Noncooperative firms: distribution by industry of plants, firms and volume, 1954 and 1960.

Industry	Single-plant firms						Multi-plant firms					
	Plants		Firms		Volume		Plants		Firms		Volume	
	'54	'60	'54	'60	'54	'60	'54	'60	'54	'60	'54	'60
	(percentage)											
00	9.2	10.6	12.9	16.1	6.1	7.1	19.2	24.1	8.1	11.0	28.1	33.0
01	14.9	10.6	20.8	16.1	2.6	2.0	8.3	11.9	6.6	9.6	3.9	2.9
02	7.2	5.0	10.0	7.6	4.6	2.9	10.9	11.5	5.5	6.8	14.0	14.2
03	4.5	2.0	6.3	3.1	2.7	1.6	5.3	5.9	4.2	5.6	9.1	9.9
04	1.1	0.9	1.6	1.4	1.5	1.3	1.1	1.5	1.3	2.2	1.0	1.3
07	1.3	0.6	1.8	0.8	0.6	0.4	0.6	0.9	0.5	0.8	0.3	0.4
12	1.1	0.9	1.6	1.4	3.0	2.4	0.6	0.7	0.3	0.6	3.4	3.8
13	2.3	2.2	3.1	3.4	1.0	1.5	1.1	1.3	1.6	1.1	1.4	1.2
01-04	0.8	0.7	1.0	1.1	0.1	0.2	1.1	1.3	1.0	2.0	2.9	2.1
01-13	0.2	....	0.3	....	0.1	....	....	....	....	....	....	....
02-01	2.6	1.5	3.7	2.2	0.7	0.3	0.4	0.7	0.5	1.1	0.1	0.7
02-04	0.6	0.2	0.8	0.3	0.4	0.1	0.6	0.6	0.8	0.8	1.2	0.7
02-13	....	....	....	....	....	....	0.2	....	0.3	....	0.5	....
02-03-04	0.2	....	0.3	....	0.2	....	0.2	0.2	0.3	0.3	0.1	0.4
01-02-04	....	....	....	....	....	....	0.2	0.4	0.3	0.6	0.4	0.5
03-01	0.9	0.4	1.3	0.5	0.3	0.2	2.5	2.4	2.1	2.0	6.1	5.1
03-04	0.4	0.2	0.5	0.3	0.8	0.1	....	0.2	....	0.3	....	1.0
03-12	....	....	....	....	....	....	0.2	0.4	0.3	0.6	2.3	2.3
12-13	0.2	0.2	0.3	0.3	0.6	0.5	....	....	....	....	....	....
Total	47.5	36.0	66.3	54.6	25.3	20.5	52.5	64.0	33.7	45.4	74.7	79.5

Table 11. All firms: distribution of plants, firms and volumes between single- and multi-plant firms, 1954 and 1960.

Item	1954				1960			
	Single-plant		Multi-plant		Single-plant		Multi-plant	
	number	percentage	number	percentage	number	percentage	number	percentage
Plants	270	46.7	308	53.3	218	36.5	380	63.5
Firms	270	78.7	73	21.3	218	72.4	83	27.6
Volume (000 bu.)	486,331	25.9	1,390,936	74.1	543,593	24.1	1,707,737	75.9

Table 12. Single-plant firms: distribution between cooperatives and noncooperatives.

Industry	Cooperative				Noncooperative			
	Firms 1954	Vol. 1954	Firms 1960	Vol. 1960	Firms 1954	Vol. 1954	Firms 1960	Vol. 1960
	(percentage)							
00	2.6	5.8	3.2	20.7	18.1	21.5	26.1	25.9
01	1.1	1.2	4.5	2.3	29.2	9.2	26.1	7.3
02	....	....	....	....	14.0	16.2	12.5	10.4
03	1.9	1.1	1.4	1.1	8.9	9.7	5.1	5.7
04	....	....	....	....	2.3	5.3	2.3	4.9
07	....	....	....	....	2.6	2.2	1.4	1.4
12	....	....	....	....	2.2	10.7	2.3	8.7
13	....	....	....	....	4.4	3.5	5.4	5.5
01-04	....	....	....	....	1.4	0.3	1.8	0.8
01-13	....	....	....	....	0.4	0.3	....	....
02-01	....	....	....	....	5.2	2.5	3.6	0.9
02-04	....	....	....	....	1.1	1.5	0.4	0.1
02-13	....	....	....	....	....	....	....	....
02-03-04	....	....	....	....	0.4	0.9	....	....
01-02-04	....	....	....	....	....	....	....	....
03-01	0.1	2.6	1.9	1.3	1.9	0.9	1.0	0.7
03-04	....	....	....	....	0.8	2.7	0.5	0.3
03-12	....	....	....	....	....	....	....	....
12-13	....	....	....	....	0.4	2.2	0.5	1.9
Total processing firms	4.1	4.7	7.8	4.7	75.2	68.0	62.9	51.7

about 75 percent of all firms, and multi-plant firms 75 percent of regional volume. Cooperative multi-plant firms averaged 3 and 3.2 plants per firm in 1954 and 1960, respectively, but noncooperative multi-plant firms averaged 4.4 and 4.8. For all firms in total, increases in importance of multi-plant firms are observed for plants, firms and volumes. The conjecture could be made that this increasing importance was due to the presence of multi-plant economies of size. Cost data to verify this conjecture are not available, and thus, we can only infer the presence of multi-plant economies on the basis of observed changes.

From table 1, it was evident that cooperative firms have assumed greater importance in the region. Table 12 indicates the changing importance of cooperative firms relative to noncooperatives for single-plant firms. In total, for single-plant processors, no change in importance was observed, but cooperative merchandisers were a great deal more important in 1960 than in 1954. Merchandisers, both cooperative and noncooperative, assumed a much greater share of single-plant volume in 1960. Table 13 indicates that, for multi-plant processors, cooperatives were more important in 1960 and that merchandising cooperatives were slightly less important in 1960 than in 1954.

Industry Concentration

The previous analysis centered on changes in distribution of plants, firms and volumes. It places particular emphasis on consideration of all grain buyers in the various grain-merchandising and processing categories. This analysis of firms was used with the primary objective of illustrating the changing distributions of plants and volumes among various classes of all firms. This section investigates the dominance of firms in various delineated industries in the NCR grain industry. The dominance analysis will be approached with summary techniques evaluating the changing relative importance of the largest firms. The 20 largest firms are grouped into three categories: the largest four, the largest eight and the entire 20 firms. These categories are used as a basis for distinguishing oligopolistic industries according to the degree of seller concentration (3, p. 32). Thus, component industry concentration is evaluated in an attempt to determine the degree of seller concentration in the various markets. On the selling side of the grain industries, it is these groups of firms that are competing, and intraindustry concentration indicates deviations from competitive market structure for that industry.

Table 14 provides an over-all view of industry distribution of volume among various grain-processing industries for both time periods. This table indicates the volume concentration of grain merchandising relative to each of the processing industries. These volumes represent the basis for computing market shares of the largest firm in each industry grouping.

All firms

Table 15 shows the market shares of large firms in the grain industry subgroups in 1954 and 1960. For the aggregate of merchandising and processing industries, defined as the NCR grain-marketing industry, concentration is only moderately high. This generalization is made from Bain's criterion of high concentration, in which the largest eight firms account for between two-thirds and three-fourths of industry volume (3, p. 32).

Table 13. Multi-plant firms: distribution of plants, firms and volumes among industries, 1954 and 1960.

Industry	Cooperatives						Noncooperatives					
	Plants		Firms		Volume		Plants		Firms		Volume	
	'54	'60	'54	'60	'54	'60	'54	'60	'54	'60	'54	'60
	(percentage)											
00	6.5	5.3	5.6	3.9	6.5	5.6	33.1	34.2	21.5	21.8	34.7	38.2
01	2.6	2.9	4.2	3.9	0.9	1.0	14.3	16.8	17.6	19.0	4.9	3.4
02	0.3	0.3	0.7	0.6	0.1	0.1	18.9	16.3	14.6	13.4	17.3	16.5
03	....	0.8	....	1.6	....	1.3	9.1	8.4	11.1	11.1	11.2	11.4
04	....	....	....	....	....	....	2.0	2.1	3.4	4.5	1.2	1.5
07	....	....	....	....	....	....	1.0	1.3	1.4	1.7	0.4	0.5
12	....	....	....	....	....	....	1.0	1.1	0.7	1.1	4.2	4.4
13	....	....	....	....	....	....	2.0	1.8	4.2	2.2	1.7	1.4
01-04	....	....	....	....	....	....	1.9	1.8	2.0	3.9	3.6	2.5
01-13	....	....	....	....	....	....	....	....	....	....	....	....
02-01	....	....	....	....	....	....	0.6	1.0	1.4	2.2	0.1	0.8
02-04	....	....	....	....	....	....	1.0	0.8	2.1	1.7	1.4	0.7
02-13	....	....	....	....	....	....	0.3	....	0.7	....	0.6	....
02-03-04	....	....	....	....	....	....	0.3	0.3	0.7	0.6	0.1	0.4
01-02-04	....	....	....	....	....	....	0.3	0.6	0.7	1.2	1.5	0.6
03-01	....	....	....	....	....	....	4.2	3.4	5.6	3.9	7.6	5.9
03-04	....	....	....	....	....	....	....	0.3	....	0.6	....	1.1
03-12	....	....	....	....	....	....	0.3	0.5	0.7	1.1	2.9	2.7
12-13	....	....	....	....	....	....	....	....	....	....	....	....
Total processing firms	3.2	4.0	5.6	6.1	1.1	2.4	57.2	56.5	67.3	68.2	57.7	53.8

Table 14. Grain merchandising and processing: volume and distribution by industry, 1954 and 1960, North Central Region.

Item	Grain merch. 00	Feed mfg. 01	Flour mill. 02	Oilseed proc. 03	Dry mill. cereal mfg. 04	Dist. alcohol mfg. 07	Wet-corn mfg. 12	Malt. brew. 13
1954 Volume (000 bu.)	870,930	141,653	319,535	262,361	90,245	15,247	134,050	43,246
Percentage of volume	46.4	7.6	17.0	14.0	4.8	0.8	7.1	2.3
Percentage of processing volume		14.0	31.8	26.0	9.0	1.5	13.3	4.3
1960 Volume (000 bu.)	1,136,987	123,876	311,962	322,695	98,412	16,081	157,623	51,866
Percentage of volume	51.2	5.6	14.0	14.5	4.4	0.7	7.1	2.3
Percentage of processing volume		11.4	28.8	29.8	9.1	1.5	14.6	4.8

Table 15. Market share of large firms in the grain-marketing industries, North Central Region.

Classification	Year	Number of firms	Percentage of total volume of grain accounted for by large firms: 4 largest	8 largest	20 largest
Merchandisers and processors:	1954	343	25.2	37.6	56.1
	1960	301	21.6	33.9	55.7
Merchandisers:	1954	195	45.4	55.4	71.3
	1960	185	33.2	49.8	70.8
Processors:	1954	262	22.3	37.4	57.0
	1960	216	19.0	33.1	60.0

Table 16. Market share and degree of specialization of large grain processing firms, North Central Region.

Firms	Year	Number of plants total	Number of plants processing	Volume processed (000 bu.)	Percentage of region	Specialization ratio
4 largest:	1954	30	25	224,890	22.3	89.4
	1960	47	38	211,134	19.0	76.7
8 largest:	1954	80	61	375,887	37.4	62.8
	1960	94	65	367,737	33.1	59.3
20 largest:	1954	144	113	573,237	57.0	65.4
	1960	195	139	665,908	60.0	61.4

The largest 20 firms accounted for just more than 50 percent of industry volume. Decreasing market shares indicate a relative decline in importance of the largest 20 firms in each group. The top four firms were different firms in the merchandising and processing categories for both 1954 and 1960, although there was a small overlap for the top eight and top 20. Thus, no strong tendency existed for firms to be extremely large in both merchandising and processing. In 1954, the number of firms represented in merchandising, processing or both was 457; 118 firms both merchandised and processed. The 1960 total was 401, with 100 firms in the more diversified category. This 18-firm decline in firms combining merchandising and processing was one of the factors contributing to the slight tendency for NCR firms, in total, to specialize.

All processors

The decline of firms performing processing activities was associated with a decline in market share of the top four and eight firms (table 15). These characteristics necessitated declining processing volumes for the largest eight firms, but the other 12 firms in the 20-firm group increased volume. Increases in total plants, including processing plants, for all size groups led to significant average plant volume declines. Average plant processing volume declined by 3 million bushels (33 percent) for the four largest firms whose plants process, by 800,000 for the largest eight, and by 500,000 for the largest 20 (see table 16).

The specialization ratios given in table 16 are merely summaries of the distribution of product mix between merchandising and the total of all processing activities. For specific industries, these ratios are computed by dividing the total volume of grain input to the specific processing activity by total firm volume. For specific industries, these ratios are definite indicators of diversification tendencies by the various size groups of firms. For the aggregate processing sector, however, the ratios are not complete indicators of diversification since all processing volumes are summed into one value, total processing volume.

For these large groups of processors, there was no important backward integration as might have been suggested by the increasing importance of merchandising. Specific vertical-integration data, defined as percentage of grain procured from company-owned plants, were available only for 1960; thus, no comparative analyses could be made. Forward integration for all processors, defined as percentage of grain, processed products, or both, disposed through company-owned plants was more prevalent.

In summary:

1. The largest eight grain processors controlled

a slightly declining share of industry processing volume.
2. The processing volume of firms smaller than the largest four increased relative to these four.
3. Substantial average plant volume declines occurred for the largest 20 and were greatest for the top four.

The previous analysis of grain-processing firm-size distribution was undertaken without regard for component processing industries. These industry characteristics of the aggregate processing array will be briefly discussed in the order of volume importance of processing industries.

Flour millers

Table 17 summarizes the market-share and organization data for large flour-milling firms. This industry was similar to the processing subgroup in terms of declining concentration of the largest firms. A decline in both market share and average plant volume is evident for the largest four firms. Firms smaller than the largest four grew relative to these four.

Specialization ratios were lower than the average of all processors and declined for all size groups. The declines of all size groups were associated with increases of small nonspecialty plants that caused increases in market share but had little effect on specialization. These nonspecialty plants were primarily new entrants into the industry. Diversification tendencies developed through merchandising operations and other processing activities as well. Appendix A shows merchandising as the primary diversification activity, and this tendency has increased relative to other processing possibilities. The flour-milling volume share declined. This tendency to merchandise was unrelated to backward integration.

Soybean processors

The soybean processors demonstrated very little change in concentration, but, contrary to others, increasing specialization ratios (table 18). Increases of plants were primarily accounted for by nonspecialty activities. A tendency to decrease the share of nonspecialty processing activities and to increase merchandising and soybean processing was observed. Substantially larger average plant processing volume and additional soybean plants, not only caused increased specialization, but increased market shares as well. The regional total of oilseed-processing plants declined by 15 percent caused by a decline in firm numbers, but total plants operated by the top 20 firms increased (table 18). The largest processors were substantially vertically integrated, especially in the disposition of processed products.

Feed manufacturers

Feed manufacturers exhibited significant changes among the top four firms (table 19). Similar to soybean firms, the specialization ratios increased sharply, but, contrary to other processors, total plants declined. This decline was primarily among plants that performed nonprimary activities. Table 14 indicates declining total volume for feed manufacturers; so the four largest, with constant volume, increased their share of the market. The other large firm showed diversification inclinations and little change in the moderate degree of seller concentration.

Merchandising and other processing activities were each important in these trends. An increase in number of nonspecialty plants accounted for the diversification trend. Firms smaller than the largest four are losing significance in feed manufacturing and are making compensatory volume increases in other operating activities. Vertical integration in terms of disposition of processed products was important.

Table 17. Large flour millers: market shares and specialization, 1954 and 1960.

Firms	Year	Number of plants total	Number of flour milling plants	Volume (000 bu.)	Percentage of region	Specialization ratio
4 largest:	1954	47	22	114,430	35.8	48.0
	1960	51	25	106,914	33.6	40.1
8 largest:	1954	63	36	173,440	54.3	56.0
	1960	87	45	192,374	60.5	45.8
20 largest:	1954	98	61	248,220	77.7	55.9
	1960	118	67	277,116	87.1	52.6

Table 18. Large oilseed processors: market shares and specialization, 1954 and 1960.

Firms	Year	Number of plants total	Number of oilseed processing plants	Volume (000 bu.)	Percentage of region	Specialization ratio
4 largest:	1954	47	16	112,564	42.9	29.6
	1960	65	22	143,359	41.8	38.7
8 largest:	1954	81	31	173,504	66.1	32.5
	1960	91	37	226,789	66.7	38.5
20 largest:	1954	111	45	227,524	86.7	34.7
	1960	138	50	314,354	92.4	40.9

Table 19. Large feed manufacturers: market shares and specialization, 1954 and 1960.

Firms	Year	Plant total	Number of feed plants	Volume (000 bu.)	Percentage of region	Specialization ratio
4 largest:	1954	34	21	54,910	38.8	31.9
	1960	26	18	54,210	43.3	52.9
8 largest:	1954	48	30	70,050	55.8	35.9
	1960	66	36	69,617	55.6	22.4
20 largest:	1954	103	56	108,852	76.9	19.2
	1960	124	61	91,964	73.4	17.0

Table 20. Large wet-corn millers: market shares and specialization, 1954 and 1960.

Firms	Year	Number of plants total	Number of corn milling plants	Volume (000 bu.)	Percentage of region	Specialization ratio
4 largest:	1954	7	6	103,540	77.2	80.1
	1960	13	6	108,875	69.1	77.2
8 largest:	1954	11	10	130,250	97.2	80.8
	1960	17	10	146,138	92.7	80.8
20 largest:	[a]1954	12	11	134,050	100.0	81.3
	1960	21	12	157,623	100.0	80.6

[a]1954 = 9 firms, 1960 = 10 firms.

Table 21. Large dry-milling and cereal manufacturers: market shares and specialization, 1954 and 1960.

Firms	Year	Plant total	Number of plants	Volume (000 bu.)	Percentage of region	Specialization ratio
4 largest:	1954	8	6	52,900	58.6	70.5
	1960	7	6	58,779	59.6	77.2
8 largest:	1954	24	11	72,425	80.3	45.4
	1960	45	13	84,620	85.8	39.2
20 largest:	1954	57	26	89,835	99.5	30.5
	1960	84	26	98,386	99.7	28.3

Table 22. Large malting and brewing firms: market shares and specialization, 1954 and 1960.

Firms	Year	Plant total	Number of plants	Volume (000 bu.)	Percentage of region	Specialization ratio
4 largest:	1954	8	7	25,576	59.1	73.0
	1960	11	8	33,550	62.4	59.7
8 largest:	1954	15	11	37,276	86.2	69.4
	1960	17	13	46,730	86.9	59.2
20 largest:	1954[a]	28	21	43,246	100.0	56.9
	1960[b]	25	20	53,775	100.0	62.5

[a]Data from 18 firms

[b]Data from 16 firms

Table 23. Large distilling and alcohol manufacturing firms: market shares and specialization, 1954 and 1960.

Firms	Year	Plant total	Number of plants	Volume (000 bu.)	Percentage of region	Specialization ratio
4 largest:	1954	6	5	10,450	68.5	47.4
	1960	6	5	13,542	84.2	55.2
8 largest:	1954	10	9	15,227	99.9	56.8
	1960	9	8	16,082	100.0	59.4
20 largest:	[a]1954	11	10	15,247	100.0	56.8
	1960[b]	9	8	16,082	100.0	59.4

[a]Data from 9 firms

[b]1960 data from 6 firms

Table 24. Large grain-merchandising firms: market shares and specialization, 1954 and 1960.

Firms	Year	Plant Total	Number of plants	Volume (000 bu.)	Percentage of region	Specialization ratio
4 largest:	1954	72	59	395,230	45.4	88.1
	1960	61	45	379,459	33.2	85.0
8 largest:	1954	105	78	482,240	55.4	79.3
	1960	107	82	568,758	49.8	75.8
20 largest:	1954	135	100	620,850	71.3	79.4
	1960	144	112	808,247	70.8	78.4

Wet-corn millers

Wet-corn milling is highly concentrated and specialized. There were only nine firms in the industry in 1954, and four of them controlled over three-fourths of total volume. Table 20 shows, however, that these four had a declining market share since 1954. A slight trend toward diversification has developed, primarily with nonspecialty processing plant increases. Wet-corn millers perform very little merchandising and only moderate nonspecialty processing. The small diversification trend has developed around entrants of small plants, primarily in soybean processing, and evidently not in an integration chain.

Dry millers and cereal manufacturers

Dry milling and cereal manufacturing are highly concentrated (table 21) and are increasing the degree of concentration. The four largest firms tend to be specialized. This characteristic is also increasing, associated with declines of volume and plants of nonspecialty activities, except soybean processing. For smaller firms, diversification again developed by increasing the number of nonspecialty plants, primarily soybean processing. Vertical integration was used to a moderate degree.

Maltsters and brewers

Malting and brewing firms are also highly concentrated; diversification occurred by operating more wet-corn milling plants. Average processing plant volume increases accounted for increased total volume. Concentration changed little (table 22).

Distillers and alcohol manufacturers

This industry (table 23) is characterized by a very few firms and high concentration. Mergers were not responsible for the number of firm declines. Specialization is relatively low, and merchandising is the diversification activity. The largest four firms have increased their market share significantly, and vertical integration is high, especially for disposition of processed products.

Grain merchandisers

Analysis of grain merchandising concentration is important in evaluating structural changes in the NCR grain industry since merchandising volume accounts for over half the volume distribution in 1960. Further, merchandising volume is three to four times greater than the largest processing industry. Table 24 indicates declining concentration for the top four, with smaller declines for the top eight and 20. Specialization ratios declined for the three size groups, but contrary to the processing industries, the four largest firms

operated a declining number of plants. A slight decline in the specialization ratio for the largest four was associated with an increase in average plant merchandising volume. This ratio decline developed because of a decrease of 14 merchandising plants and an increase of three processing plants. For the next 16 largest, the reverse was true; diversification developed on the basis of average processing volume increases. Similar to large processing firms, specialization declines with firm size. However, the rate of decline was much greater for processors.

Both forward and backward integration is prevalent for large merchandisers. Similar to large processors, forward integration is more important than backward. However, the levels are higher for both for large merchandisers.

In summary:

1. The grain-merchandising industry, being moderately concentrated, is becoming less concentrated.
2. The bulk of the merchandising volume is controlled by more diversified firms.
3. Diversification in the largest 20 groups of firms developed primarily through increases in average processing plant volume.
4. The largest four firms in the component industries had higher rates of diversification than did smaller firms.
5. Substantial average plant volume increases occurred for firms in the largest 20 groups.

Lorenz-curve measurements of concentration

Aggregate analysis of the largest firms in the NCR Grain Industry (table 25) reveals no tendency to increase the number of plants per firm for the largest eight group, but some increase for the next size group. Total volume increased and concentration diminished for all subgroups of the largest 20 firms. Aggregative analysis of the grain industry was accomplished by using Lorenz and cumulative-concentration curves. The Lorenz curve is a compound of two percentage distributions, the percentage distribution of the characteristic measured and the percentage distribution of the total number of firms. Obviously, the slope and height of the curves will vary, not only with the percentage of productive activity controlled by given percentages of firms, but also with the total number of firms.

The Lorenz curve of firms and plants (fig. 1) suggests two significant trend characteristics. These are increasing and decreasing concentration for different segments of the firm array as measured by the lateral deviation between curves. The focal point occurs at nineteen 1954 firms and seventeen 1960 firms in the size array, or 5.7 percent of firms. Firms larger than this experienced a slightly declining concentration of total plants,

Table 25. Market shares of large merchandising and processing firms, 1954 and 1960.

Firms	Year	Number of plants	Volume merchandised and processed (000 bu.)	Percentage of region
4 largest:	1954	70	472,863	25.2
	1960	69	486,763	21.6
8 largest:	1954	114	705,573	37.6
	1960	115	763,122	33.9
20 largest:	1954	179	1,052,722	56.1
	1960	204	1,225,084	55.7

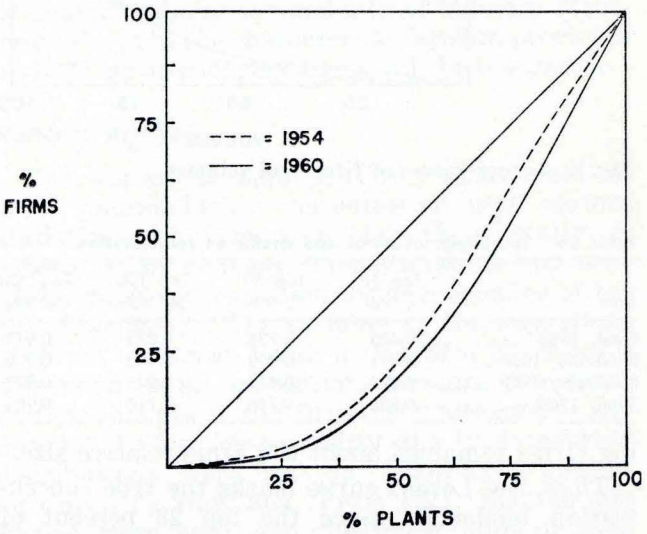

Fig. 1. Lorenz curves of firms and plants.

while those smaller had increasing concentration. The hypothesis might be advanced that, if economies of multi-plant operations exist, the large firms either did not exploit them or had already obtained the optimum number of plants, whereas smaller firms expanded the number to take advantage of these economies.

The Lorenz curve relating percentage of firms to percentage of volume is given in fig. 2. These percentage distributions indicate falling concentration for the largest 23 percent of 1954 and 1960 firms and increasing concentration for the smallest 77 percent. In terms of absolute numbers, concentration declined for the top 20 firms, as is illustrated by the cumulative concentration curve (fig. 3). This curve relates the proportion of the industry's total volume accounted for by the largest 100 firms in descending order of size on a cumulative basis. This declining concentration conclusion for the largest 20 is further verified by a criterion suggested by Prais (35) that the largest 20 1960 firms grew at a less than average rate. In terms of significant changes by segments of the firm array, the largest firm accounted for the bulk of the deconcentration, while the other top rank-

cant at the 0.01 level, and the hypothesis of log-normality was not rejected.

The means and variances of various groups of firms are shown in table 28. The results are given in terms of logs to the base 2, taken as deviations from an average size of 453,600 bushels. Equation 1 gives the combined variance of two collections of firms so that the causes for the 1954-1960 change may be assessed:

$$\sigma^2_T = w_1 \sigma^2_1 + w_2 \sigma_2^2 + w_1 w_2 (\bar{x}_1 - \bar{x}_2)^2 \qquad [1]$$

where w_1 and w_2 are the proportions of the firms in the two groups. The resulting decline in variance; and therefore, over-all business concentration was due to:

(a) the births that replaced the deaths had both a smaller mean and variance and
(b) both the mean and variance of survivors declined.

These results, relating the variance to concentration, were very similar to those developed previously by using pure concentration ratios.

Gibrat's Law of Proportionate Effects

Analysis of the size and growth of grain firms leads to a discussion of the law of proportionate effect developed by Gibrat and discussed subsequently by other authors (17, 22, 27, 35). The log-normal curve is generated by the action of random forces acting multiplicatively on a variate. Thus, the growth processes are such that firms grow by randomly distributed proportions of their original size.

The law of proportionate effect, not only requires that the distribution of survivors in the two time periods be log-normally distributed, but also requires homosecdasticity and that the regression curve of log values has a slope equal to 1. The distribution of volumes for survivors in both time periods was log-normal. This test was conducted by using the g_1 and g_2 statistics. The t - tests for both statistics were not significant at the 0.01 level, so there was little evidence of departure from normality. Volume data for 1960 were plotted against 1954 volume on logarithmic graph paper to test homoscedasticity. The resulting conditional distributions of the 1954 volume classes had dissimilar variances by χ^2 tests (27). Further, the slope of the regression line was less than 1.

The law of proportionate effect in itself is of little interest except that the law generates a log-normal distribution of firms, a distribution that closely resembles the distribution of firms in the grain industry. This size-distribution is skewed with relatively few large firms and many small firms. The more interesting aspects of Gibrat's law are the implications of the law to the growth processes of firms. Although the requirements of the law were not explicitly met, a critical examination of the implications of the growth processes leads to a fuller understanding of the growth processes of grain-industry firms.

To test the first implication, that large, medium and small firms have the same average proportionate growth, a transition matrix was constructed to evaluate firm movement to various size classes (see Appendix B). These classes were the same as those used in the previously discussed log-normal distribution. The elements on each diagonal were summed for the three groups of firms, and average proportional growth rates were computed for each group. The results were similar to others found previously in this study. Small firms, on the average, tended to double their size, but medium and large firms, on the average, were three-fourths their original size. The selection of limits for the three size categories was somewhat arbitrary. However, any change in the limits would have been to include more firms in the small class. This would tend to decrease slightly the average growth rates for small firms, but would also make the growth rates for large firms slightly less negative. Striking difference in growth rates would have existed, regardless of the values of class limits.

The second implication, that the dispersions of growth rates around a common average are the same for large, medium and small firms, was tested graphically (fig. 5). The distributions, though similar, indicate that small firms had a more skewed distribution toward higher growth rates than did either medium or large firms.

The third implication, that the distribution of proportionate growth rates is log-normal, was tested from table 29. At the 0.05 level, the g_1 statistic was not significant, but the g_2 statistic

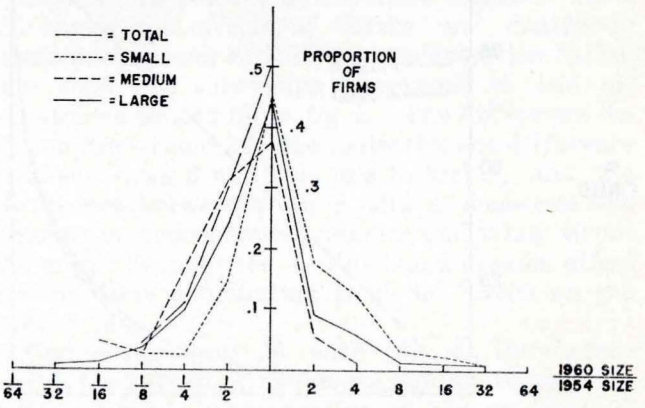

Fig. 5. Distribution of proportionate growth rates for small, medium, large and total North Central Regional grain industry firms.

was. As indicated in table 29, the distribution was nearly symetric but had an excess of moderate deviations.

The fourth implication deals with the dynamic aspects of firm growth. Firm mobility to various size classes through time is such that the variance increases. Empirical validation of this implication in this study can be tested for the 1954-60 change. The computed variance for survivors was 6.72 and 6.8 for 1954 and 1960, respectively. Following the method used by Hart and Prais (17), equation 2 was used.

$$\text{Var}_{1960} = \beta^2 \text{Var}_{1954} + \sigma\varepsilon^2 \qquad [2]$$
$$\text{Where } \rho^2 = 1 - \sigma\varepsilon^2/\text{Var}_{1960}$$

and $\sigma\varepsilon^2$ is the scatter about the regression line; r was calculated from the bivariate distribution just described. This distribution was log-normally distributed. Thus, r estimates ρ, and this value, 0.86, leads to the solution of $\hat{\beta} = 0.82$. Since $\hat{\beta} < 1$, there is regression toward the mean size for the observed distribution caused by small firms having larger proportionate growth rates.

Thus, it appears that the law of proportionate effect does not fit the data in this study. Even though the model did not fit the data, the usefulness of the empirical examination of its implications is evident. The rejection of the fourth implication of increasing variance opens the possibility of applying another theoretical model, the Markov model, by using the assumption of constant variance.

Stochastic Analysis of Industry Structure

Statistical analysis of industry structure in a dynamic context was undertaken by following a probabilistic approach. Changes in the size distribution of firms in the grain industry were evaluated by observation of firm movement between various size classes for the 1954-1960 interval. Further, the equilibrium size distribution was determined and interpreted as that unique distribution of firms that is independent of the initial distribution. This model was set up with the realization that the forces determining the size distribution of grain firms are so varied and complex that the theoretical model selected must either be extremely simplified or hopelessly complicated (5). The application of a Markov chain tends toward the former approach. But even though unrealistic simplifying assumptions are made, the value of the economic interpretation of the results is evident.

A set of different sequences and the associated probabilities is called a stochastic process. In simple terms, a stochastic process is a probability model for time series or a sequence of events (set of events ordered in time) together with the probabilities of these sequences. "Markov processes" is the term applied to a large and important class of stochastic processes (10, p. 369).

Table 29. Proportionate growth rates for NCR grain industry survivors.

1960 volume ÷ 1954 volume	1/128	1/64	1/32	1/16	1/8	1/4	1/2	1	2	4	8	16	32
Number of firms	1	1	0	3	6	22	52	95	20	12	3	2	1

A finite stochastic process is a Markov chain process if the beginning state is given and the state in any period depends only on the immediately preceding period. This dependence is assumed the same for all time transitions. This assumption is called stationarity and says that the outcome depends only on the outcome in the immediately preceding time period. Stationarity of an order of two is implied in this discussion, which means the first and second moments are invariant through time. This assumption is restrictive since there is no empirical evidence in this study that the variance of the distribution remains constant. Unfortunately stationarity and order tests are not applicable to single-transition data. This restriction, however, will not invalidate the economic usefulness of the model since both the observed transition matrix and equilibrium projections depend only on a single transition anyway.

Thus, the Markov chain process requires specification of the initial distribution in the various states, or size classes, for this study. The process moves successively from one state to another during a time sequence, and the transition probabilities, P_{ij}, of moving from S_i to S_j depend only on the previous state, S_i, that was occupied. The initial distribution specifies the starting state.

Assumptions regarding the use of the transition matrix are: (a) firms engaging in grain merchandising, processing or both can be meaningfully grouped into size classes (states), (b) that underlying determinants of change in the size distribution of firms during one time period may be represented by a probability of firm movement from one size class to another, which is independent of activity in previous periods, and (c) observed movements from class i to class j as a proportion of the initial number of firms in class i is a satisfactory estimate of the probabilities. Assumption (b) is most restrictive since we ignore all changes in supply, demand, technology, institutional policies, etc., over time and merely represent the result of all these forces by one variable —volume of grain input (21). The unit of inquiry, the transition matrix is of the form:

$$P = \begin{array}{c} \\ S_0 \\ S_1 \\ \vdots \\ S_n \end{array} \begin{array}{c} \begin{array}{cccc} S_0 & S_1 & \cdots & S_n \end{array} \\ \begin{bmatrix} P_{11} & P_{12} & \cdots & P_{1n} \\ P_{21} & P_{22} & \cdots & P_{2n} \\ \vdots & \vdots & \cdots & \vdots \\ P_{n1} & P_{n2} & \cdots & P_{nn} \end{bmatrix} \end{array} \qquad [3]$$

where: $\sum_j P_{ij} = 1$ [4]

$P_{ij} \geq 0$ for all i and j [5]

and $P^2_{ij} = \sum_v P_{iv}P_{vj}$ [6]

Induction yields:

$$P^n_{ij} = \sum_v P_{iv}P_{vj}^{(n-1)} \quad [7]$$

or the first step leads the system from S_i to some intermediate state, and the last n-1 steps from the intermediate state to S_j. Relevant theorems for the transition matrix are:

(a) For any probability vector S_j, $S_j \cdot p^n$ approaches the vector t as n tends to infinity (44, p. 71). The power terms p^n actually approach a matrix T, the rows of which are identical and equal to t (24, p. 392).

(b) The vector t is the unique probability vector such that $tP = t$ (25, p. 71).

(c) The components of t are all positive (24, p. 392).

Operationally, we need to solve the equation:

$$t\,P = t \quad [8]$$

given equation 4. Solution is accomplished by assuming the characteristic root equals 1 and by solving:

$$t' = (P'_x - I)^{-1} \begin{bmatrix} 0 \\ 0 \\ . \\ . \\ . \\ . \\ 1 \end{bmatrix} \quad [9]$$

where P_x is the matrix of n linearly independent equations in n unknowns obtained by replacing row n of P by equation 4. Adelman has provided a meaningful interpretation of the equilibrium industry structure as being "statistical in nature for the industry, and dynamic for the individual firm" (1). She further points out movement between strata is not inconsistent with the equilibrium distribution. Entry and exit to and from particular strata counter-balance opposite effects on relative distribution in the strata.

The model incorporates birth-death tendencies for the observed time period, and no projection is made of the absolute number of firms in equilibrium, the latter representing an important factor in concentration. What can be said is that, given the total firms in the stationary state, the relative importance of a given percentage of firms can be evaluated.

A summary of class limits in terms of firm concentration is given in table 30. The division of the continuous scale of firm volume was set up with two objectives in mind: (a) to have equal numbers of firms in each class for the 1954 array and (b) to have volume width of the classes that decline as firm size declines. The first objective was developed upon the basis that the transition matrix gives useful insights to the dynamic aspects of firm mobility, and thus, the matrix should be set up to provide all the meaningful information. The probability definition was manipulated to set

Table 30. Class limits for the stochastic matrix.

State	Concentration ratio range — %	1954 Volume range (000 bu.)	1960 Volume range (000 bu.)
S_0	....	....	....
S_1	0.45 - 0.100	8,500-213,000	10,400-190,000
S_2	0.166- 0.449	3,200- 8,000	3,800- 10,000
S_3	0.101- 0.165	1,900- 3,100	2,200- 3,700
S_4	0.053- 0.100	1,000- 1,800	1,200- 2,150
S_5	0.028- 0.052	530- 980	600- 1,150
S_6	0.011- 0.027	200- 500	200- 595
S_7	0- 0.010	0- 200	0- 230

$$\sum_j a_{1j} = \sum_j a_{2j} = \ldots = \sum_j a_{7j} \quad [10]$$

so that comparisons could be made between probabilities for a given column (1960). By doing this we can answer the question: "For a given state in 1960, where did firm movement originate?" The second objective was desired because larger firms are likely to grow by greater absolute amounts than smaller ones. This hypothesis stemmed from the expectation that a firm's ability to change size (volume) during this time would be related to its initial size.

Concentration ratios, rather than absolute volume, were then used to set up the states since power relations are reflected by market shares while absolute volume may not in itself be important. Further, greater inter-period comparability could be obtained from this criteria.

It can be shown that the maximum likelihood estimate of the stationary transition probabilities

$$\text{est. } P_{ij} = \frac{a_{ij}}{\sum_j a_{ij}} \quad [11]$$

where a_{ij} is the number of firms moving from state i to state j.

This definition of transition probabilities does not extend meaningfully to entrants to the industry since no empirical data were available to specify the number of potential entrants. For purposes of transition matrix observation, the assumption was made that potential entry is equal to actual entry. Given this total, the transition

probabilities may be observed to determine what portion of entrants enter into each size category. This would imply P_{00} should be zero since this cell represents the number of potential entrants remaining potential entrants. But we found that taking P_{00} equal to zero and proceeding with computations has no economic consequences on interpretation of the equilibrium vector. Obviously, the relationship between P_0 and P_j would be meaningless. It was shown that the relative values of P_j, $j \neq 0$, were unaffected by arbitrary selection of S_{00}. That is, the distribution of existing firms in equilibrium is a function of S_{ij}, $i = 0, 1, 2, \ldots 7$, $j = 0, 1, 2, \ldots 7$, $i = j \neq 0$. Even though in equilibrium, a probability for S_0 occurs, it is disregarded, and the other probabilities are normalized by multiplying t by a scalar so that:

$$t_j = 1 \qquad [12]$$

The values of P_{ij} were computed, and the matrix of results is given below. An unusual observation from this matrix is that, with the exception of the largest two classes, all firms have a considerably higher probability of leaving the industry than they do for staying in the same size class. **A priori**, one would think chances of exit would be greater for smaller firms, but the matrix confirms this only to a limited extent. The middle two classes had higher combined probabilities for existing than did classes 5 and 6. This **a priori** consideration also seems reasonable for entrants and is confirmed by observing the declining probabilities for successively larger classes. More stability in class movement for survivors is observed for larger firms, and the middle two classes were more mobile than both large and small firms.

$$P = \begin{array}{c|cccccccc} & S_0 & S_1 & S_2 & S_3 & S_4 & S_5 & S_6 & S_7 \\ \hline S_0 & 0 & 0.048 & 0.119 & 0.083 & 0.083 & 0.095 & 0.203 & 0.369 \\ S_1 & 0.224 & 0.694 & 0.082 & 0 & 0 & 0 & 0 & 0 \\ S_2 & 0.220 & 0.220 & 0.500 & 0.040 & 0.020 & 0 & 0 & 0 \\ S_3 & 0.326 & 0 & 0.196 & 0.217 & 0.152 & 0.044 & 0.044 & 0.021 \\ S_4 & 0.460 & 0 & 0.020 & 0.140 & 0.160 & 0.160 & 0.040 & 0.020 \\ S_5 & 0.333 & 0 & 0 & 0.021 & 0.146 & 0.271 & 0.187 & 0.042 \\ S_6 & 0.380 & 0.020 & 0 & 0.060 & 0.060 & 0.080 & 0.300 & 0.100 \\ S_7 & 0.620 & 0 & 0 & 0.020 & 0.060 & 0.020 & 0.060 & 0.220 \end{array} \qquad [13]$$

The equilibrium vector was computed and normalized, yielding the values:

$$t = (0.182, 0.157, 0.087, 0.101, 0.100, 0.164, 0.209) \qquad [14]$$

Comparing the 1954 and 1960 distributions showed that the median firm increased volume slightly, but declined in market share. The median firm in 1954 was at the center of S_4, whereas in 1960, it was two-thirds down the S_4 class. Analysis of the equilibrium vector suggests the median firm is in the same position in S_4 as was found in 1960. These relationships may be observed roughly in table 31. Fig. 6 shows the Lorenz curve for the seven discrete classes and is similar to fig. 2. The difference is that in fig. 6 the data are grouped rather than approximating a continuous variable. The equilibrium curve, as well as table 31, shows very little change in concentration for the various size categories, and as expected, the small observed change is in the same direction as established in the 1954-60 transition.

The stochastic matrix may be used to calculate the average mobility of firms in the various S_j states. Observation of the diagonal elements of the matrix (equation 13) suggests that a great

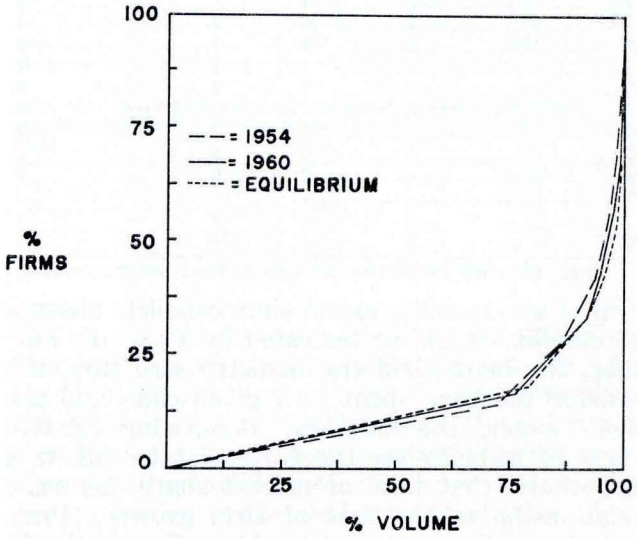

Fig. 6. Lorenz curve for seven discrete size classes.

Table 31. Distribution of firms and volumes for 1954, 1960 and equilibrium.

State	1954		1960		Equilibrium	
	% Firms	% Volume	% Firms	% Volume	% Firms	% Volume[a]
S_1	14.28	73	16.61	76.5	18.20	79.26
S_2	14.28	14	16.28	14.31	15.7	13.05
S_3	13.70	6.4	9.3	3.76	8.66	3.31
S_4	14.28	3.54	12.96	2.86	10.08	2.10
S_5	13.70	1.87	11.96	1.44	10.00	1.14
S_6	14.28	0.94	15.94	0.84	16.44	0.80
S_7	14.00	0.25	16.94	0.28	20.92	0.33

[a]Computed on the assumption that the mean firm in each class will possess the same volume in equilibrium as it did in 1960.

Table 32. Mean lifetime for NCR grain industry firms.

State	Average (years)		Perfectly mobile industry	Mobility ratios	
	All firms	Survivors only		All firms	Survivors
S_1	3.27	9.52	1.22	2.68	7.80
S_2	2.0	2.79	1.19	1.68	2.35
S_3	1.28	1.48	1.09	1.17	1.36
S_4	1.19	1.42	1.11	1.07	1.28
S_5	1.37	1.68	1.11	1.24	1.51
S_6	1.43	1.94	1.20	1.19	1.62
S_7	1.28	2.37	1.26	1.02	1.88

Table 33. Percentage of firm mobility relative to the perfectly mobile industry.

Item	1954	1960	Equilibrium
Survivors	29.97	21.56	19.10
All firms	44.66	44.63	44.05

Table 34. Extent of change in rank-group position between 1954 and 1960.

Amount of change (number of classes)	Number of firms that			
	Rose	Fell	Same	Total
0	....	....	15	15
1	7	15	....	22
2	2	10	....	12
3	4	1	....	5
4	2	0	....	2
5	3	0	....	3
6	3	1	....	4
7	0	1	....	1
8	2	1	....	3
9	1	1	....	2
10	1	1	....	2
11	1	0	....	1
12	0	2	....	2
13	0	0	....	0
14	0	0	....	0
15	1	0	....	1
Total[a]	27	33	15	75

[a]Four firms fell below class 20, and 21 firms left the industry.

deal of size mobility exists since complete absence of mobility would be indicated by $P_{jj} = 1$. Further, the more fluid the industry structure, the shorter the time spent in a given class and the more mobile the industry. Comparing relative rates of mobility for the various states allows a hypothesis that level of market share has some relationship to the rate of firm growth. Prais has shown the average time for a firm in the j^{th} state for all S_j firms (34). That is,

$$Tj = a^0_j + a^0_j P_{ij} + a^0_j P^2_{jj} + \ldots + a^0_j P^n_{jj} \qquad [15]$$

where a^0_j is the number of firms in the 1954 S_j states and P_{jj}, $i = 1, 2, \ldots, n$, the consecutive probabilities of remaining in state S_j. Therefore, the average firm will remain in the j^{th} state for a period:

$$L_j = T_j/a_j = 1 + P_{jj} + P^2_{jj} + \ldots + P^n_{jj} = 1/1 - P_{jj} \qquad [16]$$

Table 32 is the result of applying equation 16 to the data. Collins and Preston (7), following previous writers, redefined the index of industrial mobility such that the probability of entering a particular state is independent of the immediately preceding state. The equilibrium vector has the desired properties to define such an index as well as to provide a basis for comparison when evaluating the above-mean lifetimes. The ratios in table 32 suggest less mobility for large firms, but evidently middle-size firms are just as mobile as small firms. Further, the effects of deaths on mobility were removed, and the results were for survivors. Removal of birth effects was unnecessary since they do not affect the magnitude of the diagonal elements. Survivors' mobility should be lower than for all firms, and computations suggested that survivors were much more stable. This stability developed from the large number of deaths; a considerable number were large firms. The Collins and Preston index (7) was computed as follows:

$$I = \Sigma\, (1 - P_{jj}/1 - S_j)\, a_j \qquad [17]$$

where P_{jj} = the probability of firms remaining in state j,
S_j = the initial relative frequency of surviving firms in each size class and
a_j = the initial relative frequency of volume in each size class.

Thus, the actual mobility of firms in each size class as a percentage of the possible mobility under perfect mobility may be computed by using the relative frequency distribution of volume by size class as weights. The results of computation of the index for both survivors and all firms are given in table 33. The values indicate survivors were much less mobile than all firms and became even less mobile since 1954. No significant declines have occurred for all firms. Thus, the present high level of exit from the grain industry has accounted for the present level of firm mobility. A subsequent analysis of mergers will reveal the causes for firm deaths.

The previous mobility discussion emphasized relative volume changes of firms. Another measurement method was used that focuses on firms' changing industry rank (20). This method studies the rank-shift pattern of firms by identifying changes in each firm's rank in the time interval. The procedure involved classifying the top 100 firms into 20 classes, each class width being 5. The top 100 had combined volumes of 87 percent of the industry. A transition matrix was set up to observe firm movement to different rank classes. Complete rigidity would be indicated by a single diagonal of fives. A summary of rank changes is presented in table 34.

The transition matrix indicated that a slight

majority of rank decreases occurred between the ranking of 11 and 55. Most increases occurred between the ranking of 56 and 95. Table 34 indicates that 75 percent of all decreases were less than 2 classes in magnitude, but 67 percent of all increases were greater than 3 classes. To quantify the variation from the diagonal, a correlation coefficient of 0.77 was computed. This value understates industry fluidity for three reasons: (a) firm deaths could not be incorporated into computations, (b) the movement of firms below rank 100 were not included and (c) the variation did not account for intraclass movement.

A comparison of the average percentage volume change necessary to move a firm to one higher class was made with the aggregate percentage volume change of the top 100. This comparison was necessary to insure that minor differences in growth rates did not produce wide jumps in rankings. The top 100 increased total volume by 25 percent, and the average percentage increase in volume necessary to move up one class was 52 percent. Thus, we can be assured that the observed rank changes required growth rates of much greater magnitude than the average rate of growth. Although no norm exists by which to interpret the correlation coefficient, its value and the supplementary reasons for understatement of industry fluidity lead to the conclusion that industry structure is much less than completely rigid, especially when births and deaths are included.

Primary Growth Processes

We now turn to a discussion that logically follows the mobility analysis; that is, given the present level of firm growth, what are the primary growth processes? Further, the Markov model will be used to determine the rate of diversification changes as equilibrium is attained.

Analysis of the stochastic transition matrices of specialization ratios for all survivors (table 36) and all firms (table 37) revealed the specialization and diversification tendencies within the distribution. Table 35 gives the specialization class limits used in these matrices. The survivor matrix (table 36) confirms an initial hypothesis that diversification and specialization are not mutually exclusive growth characteristics for the aggregate distribution.

The most diversified firms in 1954 tended to increase specialization a great deal more than the most specialized tended to diversify. Table 36 for survivors suggests that firms in the B and D specialization class in 1954 contributed most to this tendency. The results in this matrix are in terms of firm number, the size factor being unaccounted for.

To relate size to diversification tendencies, both

Table 35. Class limits for transition matrices in terms of specialization ratios.

Class	Limits
A	0.97 - 1.00
B	0.85 - 0.96
C	0.60 - 0.84
D	0.40 - 0.59

Table 36. Survivors' matrix of specialization ratios.

Class	A	B	C	D
A	0.86	0.06	0.04	0.04
B	0.48	0.17	0.30	0.05
C	0.17	0.12	0.54	0.17
D	0.13	0.04	0.54	0.29

Table 37. All firms' matrix of specialization ratios.

Class	O	A	B	C	D
O	0	0.75	0.07	0.09	0.09
A	0.40	0.51	0.04	0.02	0.03
B	0.28	0.34	0.13	0.22	0.03
C	0.28	0.12	0.09	0.39	0.02
D	0.29	0.09	0.03	0.38	0.29

Table 38. Largest 50 survivors' matrix of specialization ratios.

Class	A	B	C	D
A	0.90	0.05	0	0.05
B	0.33	0.17	0.50	0
C	0.15	0.23	0.54	0.08
D	0	0	0.46	0.54

Table 39. Second 50 survivors' matrix of specialization ratios.

Class	A	B	C	D
A	0.87	0.08	0.03	0.02
B	0.63	0.13	0.24	0
C	0.33	0.33	0.33	0
D	0.50	0.50	0	0

the top 50 and the next 50 survivors' specialization ratios were traced (tables 38 and 39). For the top 50 firms, the most highly specialized firms tended to stay specialized. Those firms in the second highest class displayed predominant diversification tendencies, but firms in the other classes tended to increase specialization.

To test the adequacy of the arbitrary class limits, new limits were set up by using equal class intervals for the top 50. The results are not shown, but they were quite similar to those previously discussed. The second 50 firms analysis (table 39) using both limit schemes led to results similar to those for the top 50. Diversification tendencies for the top 50 appear similar to those of smaller firms, with one exception. The larger firms not highly specialized did not increase specialization at as high a rate as did smaller firms.

The hypothesis is that increases in specialty operations will predominate through time for those firms not initially in the highest specialty

Table 40. Surviving firms: frequency distributions of specialization ratios.

Class	1954	1960	Equilibrium
A	59.4	60.8	61.9
B	10.6	8.3	8.2
C	18.9	21.7	21.0
D	11.1	9.2	8.9

Table 41. All firms: frequency distribution of specialization ratios.

Class	1954	1960	Equilibrium
A	63.7	64.8	67.5
B	9.4	8.0	7.8
C	16.8	18.2	15.9
D	10.1	9.0	8.8

Table 42. Largest 100 firms: frequency distribution of specialization ratios.

Class	1954	1960	Equilibrium
A	57.0	61.0	68.7
B	14.0	11.0	10.5
C	16.0	19.0	14.7
D	13.0	9.0	6.1

Table 43. Calculated multiple regression statistics for NCR grain industry firms.

Group of surviving firms[a]	α	β_1	β_2	Partial correlations	Av. rank change
Largest 50 in 1960	-0.64	-0.001[b]	0.03	0.019	-0.44
Rank 51-125 in 1960	-1.45	-0.026[b]	-0.15	-0.044	-0.99
Rank 126-190 in 1960	-3.09	-0.079[b]	0.28[b]	0.217	-1.42
Largest 20 1960 processors	-0.03	-0.001[b]	0.21[b]	0.437	....
Grain merchandisers, 1960	-2.07	-0.001[b]	-0.03	-0.010	....
Grain processors, 1960	-1.34	-0.009[b]	0.34[b]	0.125	....

[a]No births or deaths included.
[b]Significantly different from zero at 0.01 level.

class, but most of those initially highly specialized will tend to diversify. To test this hypothesis, the relative frequency distributions were calculated for various groups of firms for 1954, 1960 and equilibrium. The relative frequency distributions for survivors are given in table 40. Classes B and D decrease in relative frequency with compensatory increases in classes A and C. Table 41 includes birth and deaths, and in all classes but A, a tendency toward lower frequency existed. Table 42 is for the top 100 survivors and illustrates results similar to the total firm array.

Table 42 is very important for formulating conclusions since the results in tables 40 and 41 are heavily biased toward characteristic changes of small firms because of the large number of small, highly specialized firms represented in the latter matrices. If the results for the top 100 had been different from those for all firms, the conclusions developed from survivors and all firms would have been less interesting since the top 100 control about 87 percent of industry volume. Thus, the hypothesis is not rejected. Increases in specialty operations can be expected to remain important to firm size under existing growth processes. Many firms are continually moving from the highest specialty class to more diversified classes, but since more firms are becoming or remaining highly specialized, the predominancy, in terms of number of firms, is toward greater specialization. The tendency, in terms of total firms and weighted by firm volume, is toward increasing importance of diversification. The latter conclusions were developed previously in this study.

Another relationship that was tested was suggested by Gort (14). Gort inferred that diversification is related to concentration in that diversification is more likely to occur if the primary activity were in a relatively highly concentrated industry. Frequency distributions were set up relating the extent of firm diversification (change in product mix) and the level of concentration within the primary product industry. The level consisted of ranking the eight industries by level of concentration. There was a distinct correlation between specialization and level of concentration; that is, specialization tended to occur in those industries of relatively lower concentration. Firms whose primary activity was in a relatively higher concentrated industry displayed only a slightly greater tendency to diversify than did other firms.

Gort has indicated (14, p. 66) that diversification, being a form of investment and therefore contributing to total firm size and the ability of large firms to raise investment funds, contributes to the positive relation between size and diversification. However, there was no observable relationship between diversification tendencies (defined as change in product mix) and firm size. There was, however, an observable relationship between firm size and diversification tendencies when diversification was defined as an increase in the heterogeneity of markets served.

The relationship between diversification tendencies and firm rate of growth was tested in the belief that "a rapidly growing, and hence more successful company is, under some circumstances, likely to diversify more" (14, p. 75). The hypothesized positive relation between growth and diversification was tested by multiple regression according to the following model:

$$Y = \alpha + \beta_1 X_1 + \beta_2 X_2 \qquad [18]$$

where

Y = the change in rank between 1954 and 1960,
X_1 = the change in average plant volume and
X_2 = the change in specialization ratio.

The coefficients were computed for various size classes of firms. The results are shown in table 43. All equations yielded significant F tests

at the 0.01 level. The X_1 variable represents the plant size component of total firm size. The coefficients for the X_2 variable show the observed relationship between changes in rank and changes in specialization. The regression coefficients and partial correlations provide a good summary of diversification tendencies. The largest firms showed a small positive relationship between rank change and specialization. A substantial volume increase was necessary in all cases to increase firm rank. Diversification was the tendency for the next 74 firms, but the smallest 64 firms predominantly specialized when increasing rank. Thus, as previously indicated, there is no evident relationship between size and diversification tendencies. Processors tended to specialize, and merchandisers tended to diversify when increasing rank.

Computation of average rank changes for firms in the various 1960 size categories permitted observing the relationship between rate of growth and diversification tendencies. Again, no obvious relationship existed. One must not be misled by use of rank changes as a growth measure. The negative averages were associated with average volume increases. Further, these calculations are for the 1960 size group. Since these are not 1954 size groups, the averages cannot be interpreted as growth characteristics of firms of various sizes. It would be necessary to calculate these averages for the 1954 group before conclusions were formed. Previously, it has been shown that smaller firms have grown relative to large firms.

To ascertain the effects of another growth process, merger, on the relative inequality of the firm distribution, data were needed on the identity of all participants of the merger process for both time periods. This analysis helps explain the decline in relative inequality and over-all concentration, as indicated in table 28. The over-all effects on the 1954 and 1960 distributions due to merger activity were determined by two factors: (a) the variance changes of all firms engaged in mergers and (b) the effects on the parent distribution due to merger activity. Table 44 gives the statistics of firms directly involved in the merger process. A significant decline in the variance was recorded, as well as an increase in the average size firm. The effects of mergers on the relative inequality of the size distributions over time are

Table 44. Calculated statistics of firms involved in 1954-1960 mergers.

Item	Before mergers[a] (1954)		After mergers (1960)
	Acquired firms	Total	Total
Number	46	75	29
Mean[b]	2.28	3.44	5.38
Variance[b]	5.66	6.25	4.03

[a]Acquiring firms were not all in operation in 1954, because of a complete reorganization of 2 or more firms into a new 1960 firm, in certain cases.

[b]In units of Log to the base 2, from working mean of 453,600 bu.

Table 45. Effects of 1954-1960 mergers on the variances of firm sizes.

Firms	Variance
1954 Total	6.88[a]
1954 Total, subtracting acquired firm	7.32
1960 Total, substracting acquirings' 1960 acquired volume	6.31
1960 Total	6.56

[a]In units of Log to the base 2, from working mean of 453,000 bu.

given in table 45. The over-all merger effects were broken into the effects of the acquired firms on the 1954 distribution and the effects of the acquiring firms on the 1960 distribution. The latter effects were somewhat different from the former since six acquiring firms were entrants to the industry, and the remaining 23 were industry survivors.

To determine the merger effects on the 1960 distribution of the acquisitions, it was necessary to remove the acquired firms' 1960 volume from the 1960 acquirers' volume. The variance increases, row 4 minus row 3, due to mergers developed by the merging of very large firms with those near the mean size. Still, relative inequality declined because firms not involved in mergers regressed toward the mean with a greater compensatory declining effect on the variance. These effects were similar to those observed in the concentration ratio analysis though not identical. Variance analysis considers a different aspect of structural change, although they are substitutes for each other for formulating general conclusions. Changes in the variance were caused by changes in firm volume, but changes in concentration ratios are caused by changes in firm volume relative to other firms. The latter deals with changes in proportions, the former with absolute volume changes.

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APPENDIX A

Table A-1. Flour milling: volume of grain by firm size category, 1954 and 1960.

Firms	Year	00	01	02	03	04	07	12	13
4 largest:	1954	27.6	7.7	48.0	14.5	2.3	....	....	....
	1960	43.0	2.0	40.1	12.3	2.6	....	....	....
8 largest:	1954	25.1	5.9	56.0	11.2	1.8	....	....	....
	1960	42.1	1.7	45.8	8.4	1.7	....	....	....
20 largest:	1954	28.2	4.8	55.9	8.3	2.8	....	....	....
	1960	37.5	1.6	51.0	8.2	1.5	....	....	....

Table A-2. Oilseed processing: volume of grain by firm size category, 1954 and 1960.

Firms	Year	00	01	02	03	04	07	12	13
4 largest:	1954	54.9	2.3	8.5	29.6	0.01	....	4.7	....
	1960	52.9	7.1	....	38.7	1.2	....	....	....
8 largest:	1954	41.2	8.3	12.9	32.5	1.8	....	3.3	....
	1960	47.7	4.6	4.7	38.5	1.0	....	3.5	....
20 largest:	1954	38.9	7.9	13.4	34.7	2.4	....	2.7	....
	1960	39.1	4.6	9.5	40.9	3.3	....	2.6	....

Table A-3. Feed manufacturing: volume of grain by firm size category, 1954 and 1960.

Firms	Year	00	01	02	03	04	07	12	13
4 largest:	1954	8.5	31.9	21.3	15.8	22.5	....	....	....
	1960	13.0	52.1	....	10.6	4.2	....	....	....
8 largest:	1954	12.2	33.7	18.9	15.9	17.6	....	....	....
	1960	52.1	21.3	0.3	23.8	1.4	....	....	....
20 largest:	1954	43.9	18.3	12.1	18.1	7.0	....	....	0.7
	1960	42.7	16.4	14.6	17.5	7.0	....	1.2	....

Table A-4. Wet-corn milling: volume of grain by firm size category, 1954 and 1960.

Firms	Year	00	01	02	03	04	07	12	13
4 largest:	1954	0.4	....	....	19.5	....	....	80.1	....
	1960	1.8	0.5	....	14.3	0.2	....	77.2	....
8 largest:	1954	0.3	....	....	15.6	....	....	80.8	3.2
	1960	1.4	0.4	....	11.2	0.2	....	80.8	6.1
20 largest:	1954	0.3	....	....	15.3	....	....	81.3	3.1
	1960	1.6	1.1	....	10.9	0.2	....	80.6	5.7

Table A-5. Dry milling and cereal manufacture: volume of grain firm size category, 1954 and 1960.

Firms	Year	00	01	02	03	04	07	12	13
4 largest	1954	5.0	11.8	4.7	8.0	70.5	....	....	....
	1960	3.0	4.1	....	15.8	77.2	....	....	..
8 largest:	1954	5.6	16.2	25.1	7.8	45.4	....	....	....
	1960	7.9	13.0	14.1	25.8	39.2	....	....	....
20 largest:	1954	9.1	18.7	22.7	13.8	35.6	....	....	....
	1960	13.7	10.0	14.5	26.2	28.0	....	5.1	2.4

Table A-6. Malting and brewing: volume of grain firm size category, 1954 and 1960.

Firms	Year	00	01	02	03	04	07	12	13
4 largest:	1954	11.9	....	....	....	....	....	15.2	73.0
	1960	7.7	....	....	....	0.5	....	32.0	59.7
8 largest:	1954	8.5	12.2	....	....	....	....	9.9	69.4
	1960	7.5	....	....	....	0.4	....	32.9	59.2
20 largest:	1954	16.8	9.5	9.9	....	....	....	7.0	56.9
	1960	6.9	....	....	....	0.3	....	30.2	62.5

Table A-7. Distilling and alcohol manufacture: volume of grain firm size category, 1954 and 1960.

Firms	Year	00	01	02	03	04	07	12	13
4 largest:	1954	52.6	....	....	....	....	47.4	....	....
	1960	44.8	....	....	....	....	55.2	....	....
8 largest:	1954	43.2	....	....	....	....	56.8	....	....
	1960	40.6	....	....	....	....	57.3	....	....
20 largest:	1954	43.2	....	....	....	....	56.8	....	....
	1960	Only 6 firms in 1960							

APPENDIX B

Table B-1. Transition matrix for NCR grain industry survivors.

Upper limit classes	1954 Size Class A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Total
10.....A																	
20.....B									1								1
40.....C	1		1	1	1												4
80.....D			1	2	1		1										5
160.....E				1	1	1	1	1	2								7
320.....F				1		7	1		1	1							11
640.....G					2		14	8	6					1			31
1,280 .....H					1	4	4	14	6	3	1						33
2,560 I						1	3	9	12	8	6						39
5,120 .....J							1		2	14	12	3	1				33
10,240 .....K										3	6	8	2	1			20
20,480 L								2		1		11	4				18
40,960 .....M								1					3	1			5
81,920 .....N														8	1		9
163,840 .....O															1		1
327,680 .....P																1	1
Total	1	0	2	5	6	13	25	35	30	30	25	22	10	11	2	1	218