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U.S. FARM NUMBERS, SIZES, AND RELATED STRUCTURAL DIMENSIONS: PROJECTIONS
LIN, W. ; COFFMAN, G. ; PENN, J.B. 1 OF 1

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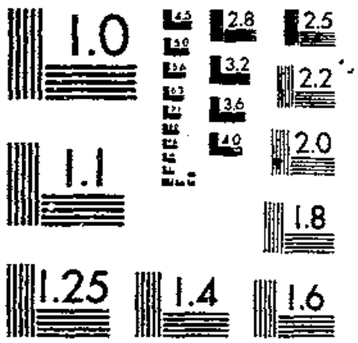

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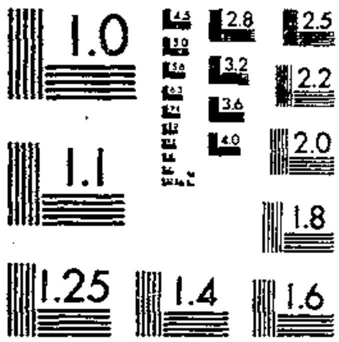

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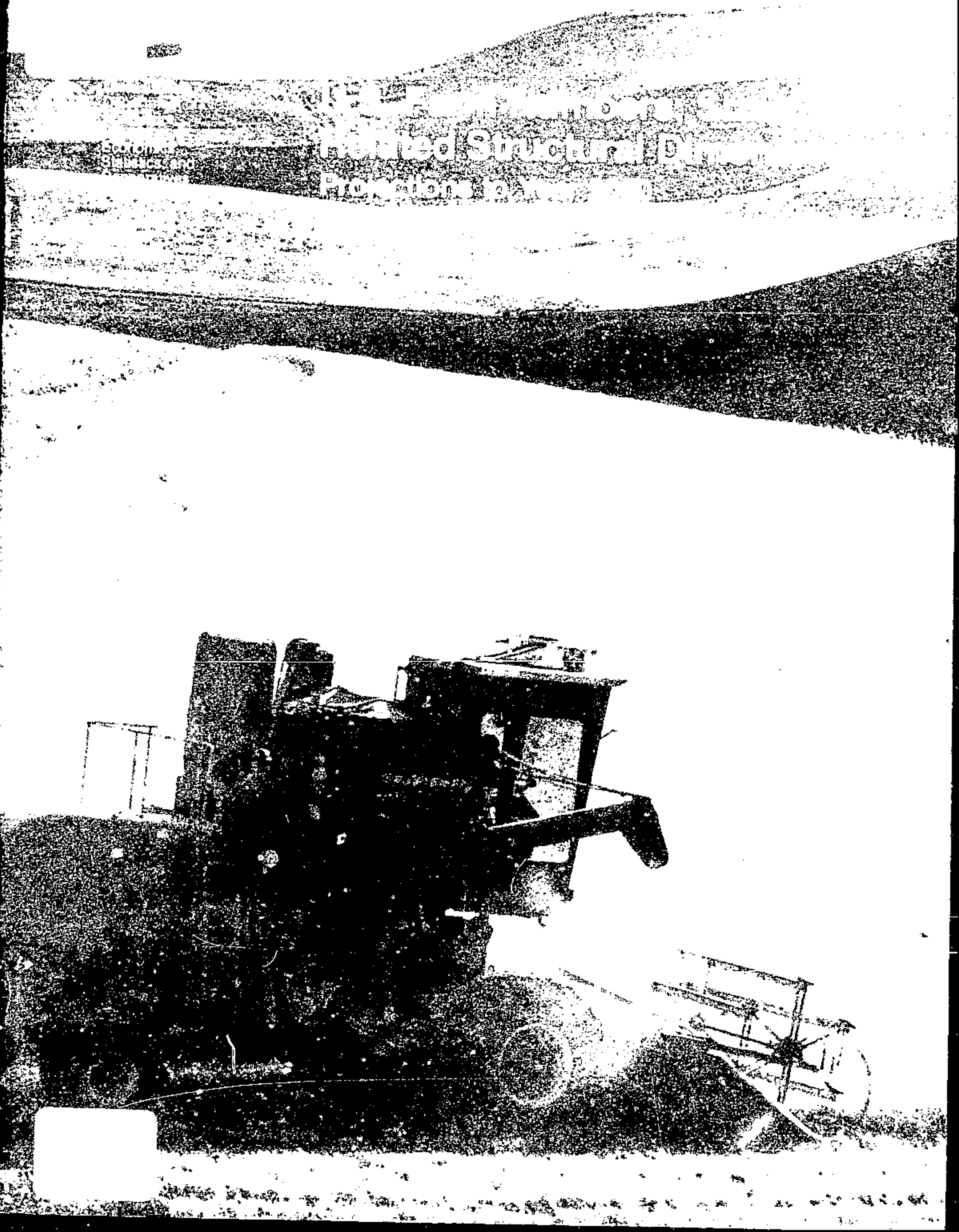

Structural

U.S. FARM NUMBERS, SIZES, AND RELATED STRUCTURAL DIMENSIONS: Projections to Year 2000. William Lin, George Coffman, and J.B. Penn. National Economics Division; Economics, Statistics, and Cooperatives Service; U.S. Department of Agriculture. Technical Bulletin No. 1625.

ABSTRACT

The number of U.S. farms is projected to continue to decline through the end of the century--from 2.9 million in 1974 to 1.8 million in 2000. The proportions of small and large farms will change as well, with large farms increasing and dominating agricultural production. Farm production, farmland, and farm wealth will become more concentrated; farm operators will rent more of their farmland and will produce more of their commodities under contractual arrangements with food processors. The projections are based on four analytical methods: trend extrapolation, negative exponential functions, Markov process, and age cohort analysis.

Keywords: Farm structure, Farm numbers, Farm sizes, Trend extrapolation, Negative exponential functions, Markov process, Age cohort analysis, Concentration of ownership, Specialization, Capital requirements.

The following reports published by ESCS also deal with the structure of U.S. agriculture.

Status of the Family Farm: Second Annual Report to the Congress. AER-434. September 1979.

Structure Issues of American Agriculture. AER-438. November 1979.

Another Revolution in U.S. Farming? Lyle P. Schertz and others. AER-441. December 1979.

ACKNOWLEDGMENTS

The authors acknowledge with thanks the comments and suggestions of Emerson Babb, Dave Harrington, Levi Powell, Donn Reimund, Allen Smith, and Alan Walter. Tom McDonald edited the manuscript. Appreciation is also due Ronald Miller for his computation assistance for the negative exponential functions chapter, and Roy Hatch for his preparation of an earlier version of the Markov process chapter. Several technical support people made important contributions. They include: Dana Anthony, Carol Collins, Angie Kennedy, Virginia Minter, Terry Salus, Jennifer Reed, and Sandy Swingle.

Washington, D.C. 20250 July 1980

CONTENTS

SUMMARY

The total number of farms in the United States will decline from 2.9 million in 1974 to 2.1 million in 1990 and to 1.8 million in 2000 if present trends continue. The farms will probably be arranged in a bimodal distribution--a large proportion of small farms, an ever-increasing proportion of large farms, and a declining proportion of medium-size farms. Small farms (gross sales of less than $20,000) will constitute about 50 percent of all farms in 2000, a decline from 72 percent in 1974, while the proportion of large farms (gross sales of more than $100,000) will increase from 5 percent to 32 percent.

The projections deemed most likely to be realized are summarized as follows:

Sales class	1974	1985	1990	2000
		1,000 farms		
Less than $20,000	2,070	1,416	1,193	889
$20,000 - $99,999	655	563	450	301
$100,000 - $499,999	139	290	358	344
$500,000 and over	11	51	88	217
All farms	2,875	2,320	2,090	1,750

Much of the shift to larger farms will be due to the expected rise in the index of prices received by farmers rather than a rise in the real output per farm. For example, the number of farms with sales of $100,000 or more is projected to increase four times between 1974 and 2000 in current prices compared with an increase of 2.7 times in that period if constant (1964) prices are used. If the rate of price increases through the year 2000 is less than that projected, the numbers of farms in each sales class will change: the number of farms in the larger sales classes will be reduced and the number of farms in the smaller sales classes will be increased.

The decline in farm numbers and the increase in farm size will probably be accompanied by other changes in the structural characteristics of the U.S. farm sector. The highlights are:

- Agricultural production and farmland ownership will be dominated by fewer and fewer farms. By 2000, the largest 1 percent of farms will account for about half of all farm production. By contrast, 50 percent of the farms--the smaller ones--will produce only 1 percent.

- Almost two-thirds of the production will likely come from the largest 50,000 farms and nearly all farm products will be produced by the largest 1 million farms in 2000.

- By 2000, about 96 percent of total farm production is projected to come from farms with sales of at least $100,000. About 54 percent came from such large farms in 1974.

- About 57 percent of the farmland will be operated by farms containing at least 2,000 acres. The corresponding percentage in 1974 was 42 percent.

- Half of the farmland will be farmed by the largest 50,000 farms, and almost all of the land will be operated by the largest 1 million farms.

- Capital requirements will rise to about $2 million of capital assets per farm for farms with sales of more than $100,000--nearly double what was required in 1978.

- The accelerating capital requirements imply that the low-equity, young, potential farmers will have even more difficulty getting started in farming.

- Large capital requirements and large farms will tend to concentrate farm wealth in the hands of a few. By 2000, two-thirds of the wealth in the farm sector will be in the hands of those who have an interest in farms with more than $100,000 in sales.

- The number of new farmers under 35 years of age will shrink from 475,000 in 1964-74 to 284,000 in 1994-2004, a 40-percent decrease.

- The number of corporations in farming will continue to increase, while the number of partnerships will decline. Multiownership farms (corporations and partnerships) may account for half of all farm sales by the end of the century. The number of corporations might nearly triple by that time; even if they did so, however, farm corporations would still constitute less than 4 percent of the total farms.

- Part owners will account for a third of all farms by 2000 and more than two-thirds of large farms (sales of more than $100,000). In 1974, part owners accounted for 27 percent of all farms and 57 percent of large farms. (Part ownership means that a farmer owns some farmland but rents the remainder from others.)

U.S. Farm Numbers, Sizes, and Related Structural Dimensions:
Projections to Year 2000

William Lin
George Coffman
J.B. Penn

INTRODUCTION

The U.S. farming sector has undergone significant structural changes over the past few decades, and is expected to continue changing. Perhaps the most obvious of the changes is in farm numbers and sizes. The Census of Agriculture counted 4 million farms in 1959 and 2.9 million in 1974; that number is expected to decline to 1.8 million in 2000. The average farm size is increasing as farm numbers decline, with the consequent concentration reflected in production. The largest 4 percent of the farms accounted for about a third of the value of farm products sold in 1959 and 43 percent in 1974. By 2000, the largest 1 percent of the farms will account for about half of all farm production. 1/

This trend toward greater concentration--fewer but larger farms--is the result of the interaction of many factors: technology, economies of size, tax laws, returns to resources, price instability, operator's managerial ability, capital requirements, market conditions, farm programs, credit availability, exchange arrangements, government regulations, and the like. While it is recognized that these factors have immediate effects on the farm sector, their effects on the structure of agriculture are of a longer term nature.

1/ The projections in this report are based on historical data--up to and including data from the 1974 Census of Agriculture, the most recent available. Another Census of Agriculture was conducted in 1978, but data from that census are not expected to be fully compiled and available until late 1980.

Thus, an interesting question is: What will the farm structure of the future be, barring major shifts in the course of events or the underlying causes? This report addresses that question by using four analytical methods (trend extrapolation, negative exponential functions, Markov process, and age cohort analysis) to project future farm numbers and sizes.

These methods are compared and evaluated in terms of the accuracy of their projections. From this examination, a set of most likely projections was selected, and the implications of the projections for size-related structural dimensions examined--how they relate to current structural concerns, including the concentration of production, control of land resources, form of business organization, barriers to entry, capital requirements, distribution of wealth, separation of resource ownership and use, contracting arrangements, and farm specialization.

The projections presented are not forecasts; that is, they are not best judgment estimates of what will actually exist at the turn of the century. Rather, they are most useful as providing a boundary notion of where the present trends are likely to lead, in the absence of significant changes in the underlying forces. It is certain, however, that changes not yet anticipated will occur.

The projections and implications presented here, even with their acknowledged limitations, may prove useful for long-term planning by agribusiness, academicians, and government institutions. Agribusiness may find them useful for planning business activities related to input supply and product processing. The projections may also suggest research and extension activities. Government may find the projections of use for planning research, for projecting revenues and expenditures, and for examining long-term public policy options to influence the structure of agriculture.

OVERVIEW OF STRUCTURE AND STRUCTURAL CHANGE

This chapter describes the current situation for some elements of the structure of U.S. agriculture and recent changes in structural characteristics, emphasizing those related to size. The reader then can compare the current situation with that projected for the future described in the next chapter.

The land in farms declined only slightly between 1940 and 1974, but that relatively constant land base was occupied by fewer and fewer farms. Thus, the average farm size increased by one-third between 1940 and 1974. This change also implies increasing concentration of production and control of land resources into fewer and fewer hands.

Contrary to frequent assertion, the remaining farms, although larger, continued to be family-operated farms. Corporations still had an insignificant role in farm production and in farmland ownership. The average age of farm operators did not change noticeably from 1969 to 1974. Big farms appeared to have an edge over small farms in net farm income, payments from Government farm programs, and capital gains on farm physical assets. In 1969, off-farm income per farm was about the same for the very large and small farms. The situation differed significantly in 1974, however. Off-farm income per farm almost doubled for small farms, but no appreciable change was evident for large farms.

Although this study focuses on farm numbers and size, there are other important structural characteristics related to size, such as concentration of production and farmland, form of business organization, age and tenure arrangments of operators (discussed in the next chapter), and financial structure.

Numbers and Sizes

The land in farms increased slightly after 1940, but declined somewhat between 1950 and 1974. The number of farms, however, decreased by 60 percent while the average size(measured by acres) increased by 128 percent (table 1). The decline in the number of small farms perhaps contributed most to the increase in average size. Historically, the number of farms with less than 500 acres has steadily declined, while the number with more than 500 acres has increased (table 2). The decline in farm numbers since 1959 has been at a lower rate than that from 1940 to 1959. Many farmers left voluntarily for better opportunities in the nonfarm sectors; others who retired or died were not replaced by new farmers. The remaining farmers were often motivated by prospects of increased returns by enlarging their lands or consolidating their operations with neighboring ones. The historical trend when farms are measured by gross sales is similar to that for acreage sizes (table 3).

Concentration of Production

A major aspect of the public concern about farm structure is the concentration of farm production and control of the Nation's land. The concentration of farm production between 1969 and 1974 is shown graphically by the Lorenz curve in figure 1 (tabular data are in app. table 1). In 1969, the largest 24 percent of

Table 1--Number of farms, land in farms, and acres per farm

Year	Number	Land in farms	Average size
	1,000	Million acres	Acres
1940	6,102	1,065	175
1945	5,859	1,141	195
1950	5,388	1,161	216
1954	4,782	1,158	242
1959	3,711	1,124	303
1964	3,158	1,110	352
1969	2,730	1,063	389
1974	1/ 2,466	1,026	416

1/ Not adjusted for census underenumeration.

The number of farms reported by the Bureau of the Census is based on the 1959 definition of a farm: any place from which $250 or more of agricultural products are sold, or normally would have been sold, during the census year, or any place of 10 acres or more from which $50 or more of the agricultural products were sold, or normally would have been sold, during the census year.

The definition was changed in 1974 to exclude places with less than $1,000 of gross receipts in the census year. The effect of this change was to reduce the number of farms in 1974 from the 2.5 million to 2.3 million.

Source: U.S. Department of Commerce, 1974 Census of Agriculture, Vol. II, Part 2, June 1978.

the farms produced 80 percent of the total output. In 1974, only 20 percent of the farms were required to produce the same output. In other words, 80 percent of the output came from 655,000 farms in 1969 and from 493,000 farms in 1974. The shift of the Lorenz curve to the right illustrates this further concentration of production.

The increasing concentration of production on larger farms carries implications beyond just the numbers. Larger farms are becoming more involved with vertical integration and contractual arrangements; such arrangements suggest that farm management decisions may gradually become controlled by the nonfarm sector.

While the concentration of total farm production increased, the extent of that concentration varied widely among farm commodities. Vegetable, poultry, nursery, and greenhouse farms were more concentrated than other types of farms in 1969 (table 4). In addition, considerable increase in concentration occurred in grain, cotton, and dairy industries. Production of tobacco and forest products, as in the past, was not dominated by big farms. The same pattern of concentration was evident in 1974.

Table 2--Number of farms, by size of farm 1/

Size of farm	1974	1969	1964	1959	1954 2/	1950	1945 2/	1940	1935 2/
	Number of farms								
1 to 9 acres	168,925	162,111	182,581	244,328	484,291	488,530	594,561	509,347	570,831
10 to 49 acres	453,690	473,465	637,434	813,216	1,212,831	1,479,596	1,654,404	1,782,061	2,123,595
50 to 69 acres	160,702	177,028	211,398	258,195	346,323	427,025	472,415	510,585	581,352
70 to 99 acres	244,494	282,914	331,032	399,795	517,740	621,050	684,905	780,743	862,655
100 to 139 acres	235,056	278,752	324,652	394,505	491,458	579,244	633,851	688,479	754,076
140 to 179 acres	217,826	263,012	308,288	378,003	461,651	523,659	565,958	621,578	683,941
180 to 219 acres	137,591	165,209	191,254	225,576	257,189	275,049	282,839	279,577	294,309
220 to 259 acres	118,346	141,733	164,188	188,899	206,509	212,344	210,376	206,759	212,238
260 to 499 acres	365,369	419,421	451,301	471,547	482,246	478,170	473,184	459,003	473,239
500 to 999 acres	208,375	215,659	210,437	200,012	191,697	182,297	173,777	163,711	167,452
1,000 to 1,999 acres	93,203	91,039	84,999	136,427	130,481	121,473	112,899	100,574	88,662
2,000 acres and over	62,546	59,907	60,293						
All farms	2,466,123	2,730,250	3,157,854	2,610,503	4,782,416	5,288,437	5,859,169	6,102,417	6,812,350

1/ No adjustment for the undercounting of farm numbers by the Census Bureau was made.
2/ Alaska and Hawaii not included.

Table 3--Number of farms, by sales class, selected years 1/

Sales class	1974	1969	1964	1959	Sales class 2/	1954	1950
	Number					Number	
Less than $2,500	768,838	994,456	1,338,239	1,637,849	Less than $1,200	462,427	717,201
$2,500-4,999	289,983	395,104	443,918	617,677	Part-time	574,575	639,230
$5,000-9,999	296,373	390,425	504,614	653,881	Residential	878,136	1,029,392
$10,000-19,999	310,011	395,472	467,096	483,004	$1,200-2,400	763,348	901,316
$20,000-39,999	321,771	330,992	259,898	210,402	$2,500-9,999	811,965	882,302
$40,000-99,999	324,310	169,695	110,513	82,120	$5,000-9,999	706,929	721,211
$100,000-199,999	101,153	35,308	21,148	14,201	$10,000-24,999	448,945	381,151
$200,000-499,999	40,034	12,608	7,760	4,570	$25,000 and over	134,003	103,231
$500,000 and over	11,412	4,079	2,493	1,208			
All farms	2,463,885	2,728,139	3,155,679	3,704,912	All farms	4,783,021	5,379,250

1/ No adjustment for the undercounting of farm numbers by the Census Bureau was made.
2/ The sales classification was changed after 1954 by the U.S. Census Bureau to more adequately reflect need of users.

Concentration of Farmland Ownership

Concentration of farmland operations did not change greatly between 1969 and 1974. Eighty percent of the farmland was operated by the largest 28 percent of the farms in 1969 and the largest 23 percent in 1974 (fig. 2). This means that 80 percent of the farmland was operated by 600,000 farms in 1974. Conversely, the other 1.9 million farms controlled the remaining 20 percent of the farmland.

The concern over control of the land goes beyond the domination of large farms. It includes the extent of foreign ownership of farmland, corporate ownership, and absentee ownership in general. According to a 1978 U.S. landownership survey by the U.S. Department of Agriculture, foreigners owned 0.1 percent of all land, although the percentage varied widely in different parts of the country (19). 2/ About 30 percent of farm and ranch land was owned by only 1 percent of the landowners. Most owners were white males between the ages of 50 to 64. Sole proprietors and husbands and wives held almost three-fourths of the land in farms and ranches. Corporations held about 9 percent of farm and ranch land and non-family corporations held only 2.4 percent. Less than one-half of 1 percent of American farmland was owned by foreigners or U.S. corporations with 5 percent or more foreign ownership.

2/ Underscored numbers in parentheses refer to items listed in the Literature Cited, beginning on p. 65.

Figure 1

Concentration of Farm Production in the United States, 1969 and 1974

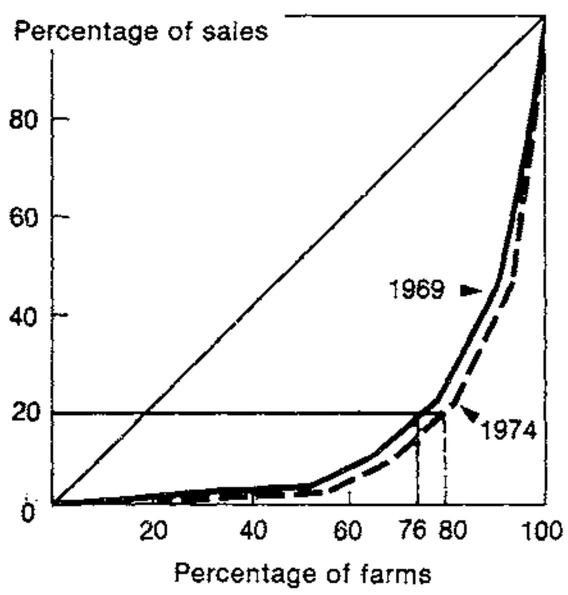
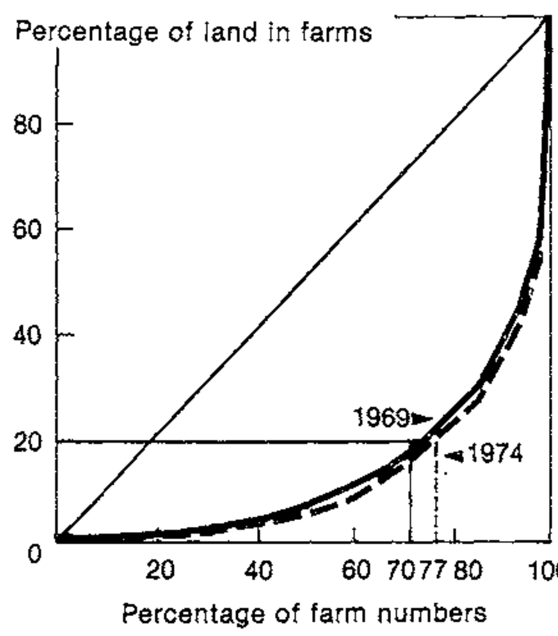


Figure 2

Concentration of Farmland among Farms, 1969 and 1974



Form of Business Organization

Contrary to common assertion that corporations are taking over farming today, the Census of Agriculture data clearly show that noncorporate farms continue to be the dominant form of business organization. Corporations were still relatively insignificant in farm production and control of the land. Moreover, more than 90 percent of the farm corporations were family-held or closely-held corporations (16 or fewer stockholders).

Corporate farms (including the family-held corporations) constituted 1 percent of the total number of farms in 1969 and 1.7 percent in 1974. These were, however, relatively large farms. The average size of corporate farms was about 3,400 acres in 1974, eight times larger than the average sole proprietorship farm. Corporate farms constituted 4 percent of the 493,000 farms which produced 80 percent of the total farm production in 1974. Overall, corporations produced 18 percent of the value of agricultural sales in 1974.

The amount of farmland controlled by corporations has never been significant and it is unlikely to become so in the near future. In 1969, corporate farms controlled about 8 percent of all farmland; that control rose to 10 percent in 1974. By comparison, the amount controlled by sole proprietorships increased from 74.5 to 76.9 percent over the same period. Farms organized as partnerships appeared to lose ground, both in terms of total farm numbers and control of farmland. During the 1969-74 period, the proportion of partnership farms declined from 11 to 7 percent; control of farmland by partnership farms declined from 17 to 13 percent.

Table 4--Concentration of production by type of farm

Type of farm	Percentage of value of products sold by class 1 farms 1/	
	1969	1974
	Percent	
Cotton and cottonseed	56.5	85.4
Dairy	42.2	74.5
Field seeds, hay, forage silage	41.5	64.5
Forest products	36.6	53.4
Fruit, nuts, and berries	68.9	82.8
Grain	38.9	75.0
Livestock	61.1	78.9
Nursery and greenhouse	85.5	90.2
Other field crops	73.5	94.1
Poultry	82.9	96.2
Tobacco	21.0	46.1
Vegetables, sweet corn, and melons	82.6	91.3

1/ "Value of products" refers to the total value of products sold by farms having $2,500 or more of sales. Class 1 farms were defined by the census as those with sales of $40,000 and over.

Financial Structure

Farm income, off-farm income, and government farm program payments constitute the major components of net income per farm (app. table 1). As would be expected, large farms had a considerably larger amount of net farm income, government farm program payments, and capital gains on farm physical assets than small farms. Although the significant reduction in Federal farm program payments in 1974 made the differences proportionally less obvious, a recent ESCS study reaffirms what is widely known about the programs--that benefits are closely proportional to production volume: the larger farms, although few in numbers, have the highest production and thus receive a disproportionate share of the program benefits (24). Of $2 billion in program payments in 1978, almost half the payments went to only 10 percent of the participants, those with the largest farms. By contrast, 50 percent of the farms--the smaller units--received only 10 percent of the payments.

In 1969, the amount of off-farm income per farm for farms with sales of more than $100,000 and less than $2,500 were about the same. This changed drastically, however, in 1974. Off-farm income per farm in sales classes of less than $2,500 almost doubled, while no significant change occurred in the top sales classes. In fact, farmers in sales classes of less than $40,000 all increased their off-farm income significantly. Preliminary data indicate that this trend continued into 1978. This suggests that small farmers are supplementing their family income through off-farm employment and investment, and that off-farm income has become more important as a source of farm family income.

Another characteristic of agriculture is the increasing ratio of debts to assets as farm size increases. In 1969, farms with sales of $20,000 or less had a ratio of 13.2 (13.2 cents of debts for each $1 of assets); farms with $100,000 or more of sales had a ratio of 24.6. By 1974, the ratio for small farms had decreased, while the ratio increased to 30.2 for the largest farms.

PROSPECTS FOR FARM ORGANIZATION

This chapter summarizes the projections to indicate where the future U.S. farm numbers and sizes are heading, and the size-related implications pertaining to the structure of U.S. farming in the following categories: concentration of farm production, contracting arrangements, specialization in farm production, concentration of farmland, form of business organization, capital requirements, distribution of wealth, age of operators and replacement rates, and tenure of farm operators.

Numbers and Sizes

The most reliable of the projections, which are described in more detail in ensuing chapters, suggest that farm numbers are likely to decline from 2.87 million in 1974 to 2.32 million in 1985, 2.09 million in 1990, 1.89 million in 1995, and 1.75 million in 2000.

The projections further reveal that future farm numbers are likely to follow a bimodal distribution--a large proportion of small farms, an ever-increasing proportion of large farms, and a declining segment of medium-size farms (fig. 3). By 2000, small farms (less than 220 acres) are projected to account for about 65 percent of the total, a slight decrease from 70 percent in 1974. By contrast, large farms (1,000 acres and over) are projected to account for about 10 percent, double their proportion in 1974 (table 5). When sales are used as the size measure, small farms (sales of less than $20,000) are projected to account for about 50 percent, a decrease from 72 percent in 1974. On the other hand, large farms (sales of more than $100,000) are projected to increase from 5 percent in 1974 to 32 percent in 2000 (table 6). The number of farms in the $100,000-to-$199,999 sales class is likely to begin declining by the turn of the century, indicating that a farm with sales of $100,000 may not be an economically viable unit in farming.

Of course, the number of farms would be still lower if the new definition of a farm, which requires minimum sales of $1,000, were applied (see table 1 footnote for new and old definitions of a farm). Using the new definition, farm numbers are likely to decline from the 2.37 million in 1978 to 2.05 million in 1985, 1.85 million in 1990, 1.66 million in 1995, and 1.54 million in 2000. The difference in the number of farms between the new and old definitions is the number of farms included in the lowest sales class (less than $2,500) by the old definition, but excluded by the new definition.

Concentration and Specialization of Production

One direct and important implication of the projections is the further concentration of agricultural production. In 1974, about half of the total farm cash receipts were received by farms with sales over $100,000. About 30 percent of the total farm production was produced by the largest 50,000 farms (2 percent of the total farms) and 60 percent by the largest 200,000 farms (7 percent of the total). Projections show that this pattern is likely to continue to 2000, and that big farms are likely to control agricultural production even more so than in the past. By 2000, about 96 percent of the total production is projected to

Table 5--Most likely projection of the number of farms, by size of farm

Size of farm	Actual 1974	1985	1990	1995	2000
			1,000 farms		
1-99 acres	1,356.9	1,096.2	989.6	894.9	826.9
100-219 acres	649.9	475.6	404.4	345.9	301.9
200-499 acres	502.1	387.4	338.6	295.8	264.3
500-999 acres	210.7	201.8	193.3	187.1	182.9
1,000-1,999 acres	93.3	97.4	98.2	100.2	102.4
2,000 acres and over	62.0	65.0	65.8	67.1	70.9
All farms	2,874.9	2,320.0	2,090.0	1,890.0	1,750.0

Table 6--Most likely projection of the number of farms, by sales class

Sales class	Actual 1974	1985	1990	1995	2000
			1,000 farms		
Less than $2,500	1,100.6	793.5	752.4	723.0	603.7
$2,500-9,999	642.4	421.1	296.8	211.7	185.5
$10,000-19,999	326.9	201.8	144.2	94.5	99.8
$20,000-39,999	327.6	204.2	158.8	111.5	87.5
$40,000-99,999	327.5	358.4	291.6	233.4	213.5
$100,000-199,999	99.4	190.2	211.1	193.7	161.0
$200,000-499,999	39.3	99.8	147.3	176.7	182.5
$500,000 and over	11.2	51.0	87.8	145.5	216.5
All farms	2,874.9	2,320.0	2,090.0	1,890.0	1,750.0

come from farms with sales of at least $100,000. This means that the 50,000 largest farms will probably produce almost two-thirds of all agricultural products, and the largest 1 million farms (57 percent of the total) will produce almost all agricultural products (table 7). 3/

Concentration of farm production can further be put into perspective by a Lorenz curve (fig. 4). In 1974, the largest 20 percent of farms produced about 80 percent of farm production. By 2000, the same percentage of farm production will likely come from the largest 12 percent of farms. More dramatically, about half the production will likely be produced by the largest 1 percent of farms. By contrast, 50 percent of the farms--the smaller ones--will produce only about 1 percent of the production.

Concentration of production is also related to two other structural factors: contractual arrangements and the economic advantages of different sizes of firms for various commodities.

Contracting Arrangements

Agricultural production under contractual arrangements has increased gradually. The percentage of farms having contracts increased from 4.5 percent in 1960 to 9 percent in 1974. Furthermore, the proportion of farms having contracts was much higher for large farms: the proportion of small farms (less than $20,000 in sales) having contracts in 1974 was less than 5 per-

3/ The concentration of agricultural production differs from commodity to commodity. Industries such as egg, poultry, and sugarcane may actually have higher concentrations than the aggregate portrayed in table 7.

Figure 3

Distribution of Farm Numbers by Sales: Actual 1974 and Projected for 2000

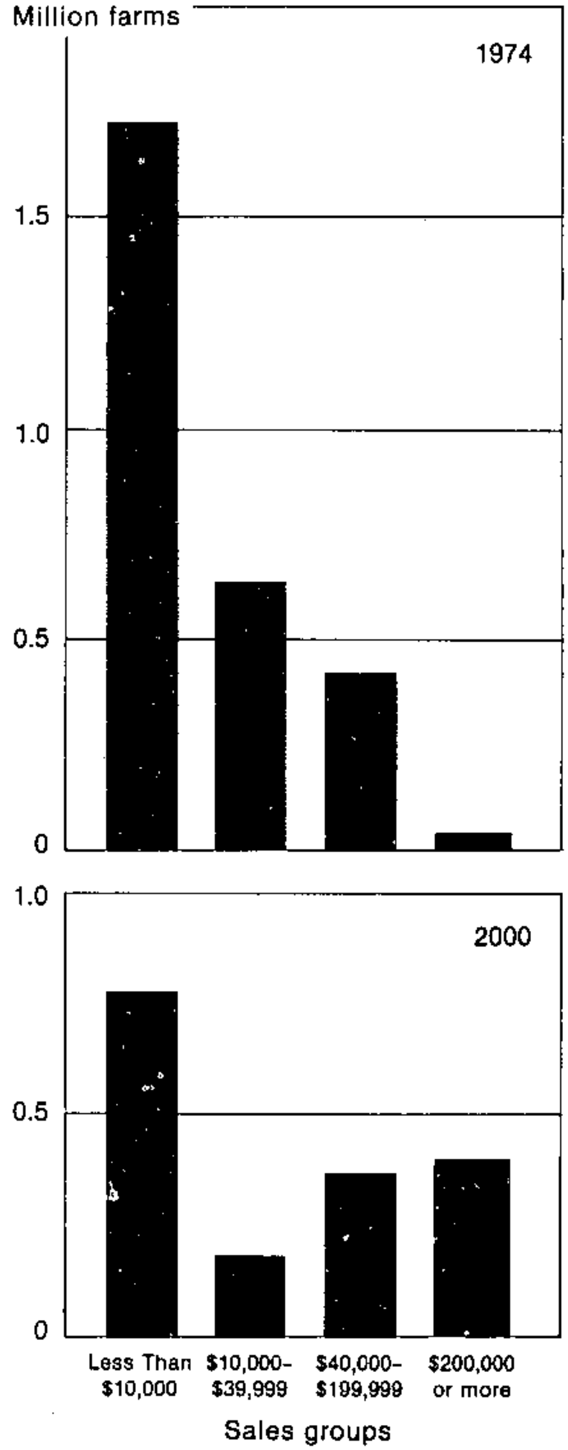
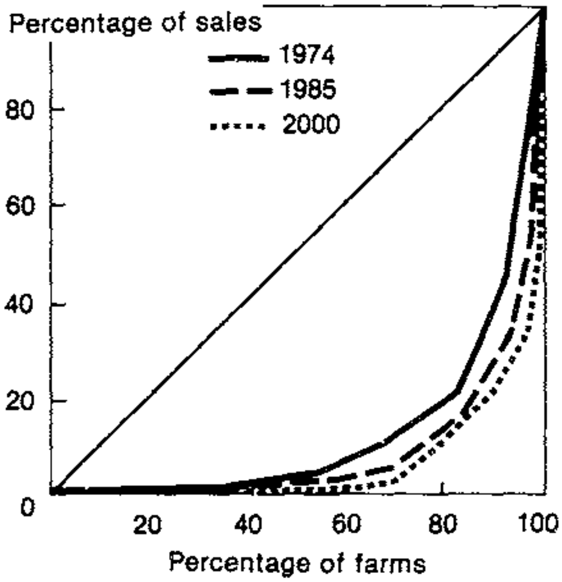


Figure 4.

Concentration of Farm Production in 1974, 1985, and 2000



cent, while the proportion was more than 30 percent for large farms ($100,000 sales or more).

The projected increase in farm size by 2000 indicates that more farms, perhaps as many as a quarter to one-third of all farms, will market their products under contractual arrangements. Virtually all production of sugarbeets and dairy products are now marketed under contractual arrangements. By 2000, contracts are likely to increase in marketing vegetables, fruits, cotton, and poultry and poultry products.

Size Variability by Commodity

Historically, some farm commodities have been dominated by large farms, and others by small farms (table 4). The changes in the farm sector reflected by our data suggest that farm production of vegetables and poultry will continue to be dominated by large farms. Other industries, such as livestock and cotton, which have recently become much more concentrated, are likely to be dominated by large farms in the future.

Table 7--Comparison of historical and projected concentration of production, by sales class and largest farms

Year	Sales class				Cash receipts by the largest		
	$500,000 and over	$100,000 to $499,999	$20,000 to $99,999	Less than $20,000	50,000 farms	200,000 farms	1 million farms
	Percent						
1969	19.5	14.1	42.6	23.8	30	50	89
1974	31.2	22.5	36.0	10.3	31	57	94
1985	47.1	34.0	15.7	3.2	54	72	98
2000	77.3	18.5	3.6	.6	63	78	99

1/ Concentration of production is expressed by the percentage of cash receipts produced by farms in a given size class; the size of farms is ranked by sales receipts.

Concentration of Farmland Ownership

Related to the concentration of production is the concentration of farmland. About 42 percent of the farmland was operated by farms having at least 2,000 acres in 1974. That meant that 35 percent of the farmland was operated by the largest 50,000 farms (2 percent of total), and 58 percent of the farmland was operated by the largest 200,000 farms (7 percent of total). The projections show continued concentration of land resources among the big farms. About 57 percent of farmland is projected to be operated by farms with 2,000 or more acres in 2000; less than 10 percent of the farmland will be in farms with less than 220 acres (table 8). Thus, half of the land will be farmed by the largest 50,000 farms (3 percent of total) and almost all farmland will be operated by the largest 1 million farms (57 percent of total).

Form of Business Organization

The number of corporations in farming is expected to continue to increase while the number of partnerships will decline slightly. Overall, the sales of multiownership farms (corporations and partnerships) could account for half of the farm sales before the end of the century. The number of corporations is projected to nearly triple, but still account for less than 4 percent of the farms.

Most of these multiownership farms will likely continue to be multifamily farms. Most new corporations will likely represent the incorporation of existing farms rather than the entry of corporations not now farming. In fact, the number of corporations could well exceed the present trends because of changes in income tax laws, more rapid rise in asset values, and new technology. Few nonfarm corporations are likely to be attracted to farming unless the profitability of farming improves greatly.

Table 8--Comparison of historical and projected concentration of U.S. farmland, by size of farm

Year	Size of farm				Farmland operated by the largest --		
	2,000 acres and over	1,000 acres to 1,999 acres	220 acres to 999 acres	Less than 220 acres	50,000 farms	200,000 farms	1 million farms
	Percent						
1969	42.8	11.6	31.1	14.5	30	50	80
1974	45.7	12.4	29.4	12.5	35	58	88
1985	47.7	13.6	27.0	11.7	40	65	93
2000	56.6	14.1	20.8	8.5	50	74	98

Financial Structure

Farms with sales of $20,000 to $99,999 required about $390,000 worth of physical and financial assets in 1978. Capital requirements were more than $1 million per farm for farms with sales of more than $100,000. Increasing farmland value and farm machinery costs will make capital requirements for farming even higher in the future. If the trend of asset-sales ratio continues, farms with sales of $20,000 to $99,999 will have assets valued at nearly $1 million per farm by the year 2000 (table 9). This is nearly triple what was required in 1978. More important, economically viable farms probably will require assets valued at almost $2 million per farm--nearly double what was required in 1978.

Much of the increase in asset values will likely result from appreciation, especially in land values. Some additional expansion of equity would arise from reinvestment of savings from income flows. These increases in equity could provide a base for additional debt. The increased debt and equity could be used to purchase more land and other capital items. Such soaring capital requirements in farming create barriers to entry, especially for low-equity, young, potential farmers.

The change in farm structure in the future will have a far-reaching effect on the distribution of wealth among farms and households that have an interest in farming.

Capital assets were dispersed about evenly among various sizes of farms in 1978--one-third each for farms with sales of: (1) less than $20,000, (2) $20,000 to $99,999, and (3) more than $100,000. The average farm required assets valued at about $267,000. By 2000, about two-thirds of the farm assets will go to farms with sales of more than $100,000, with the remaining one-third spread evenly among farms of less than $20,000 in sales and those with $20,000 to $99,999 in sales. Farm assets for all farms will average about $930,200--more than triple the 1978 figure. By 2000, two-thirds of the wealth in the farm sector will b in the hands of these farms with more than $100,000 in sales.

Age of Farm Operators and Replacement Rates

The average age of farm operators is projected to drop from 51.9 in 1974 to 50.2 by 2004 (table 10). Although this is counter to the trend up to 1974, the shift in average age reflects the higher actual entry rate of young people in the 1964-74 period. By 2004, these operators will be the middle age group, resulting in an increase in the number of farm operators in the 35 to 54 age range--from 43 percent in 1974 to nearly half in 2004. By contrast, a slight decline in the proportion of operators 55 years of age and over is projected. The projected decline in the average age of farm operators is counter to the trend observed through 1974, although the increase in average age from 1969 to 1974 was barely noticeable--from 51.2 in 1969 to 51.7 in 1974. Similarly, the percentage of farmers 55 years and over (and probably approaching retirement) increased, with the increases being especially significant in the large sales classes.

As farms become fewer and larger, fewer new farmers are needed to replace existing farm operators on adequate size farms. Therefore, the total number of net entries by persons under 35 years of age is projected to shrink from 475,000

Table 9--Balance sheet of the farming sector, by sales class

Item	Unit	Less than $20,000	$20,000 to $99,999	$100,000 and over	All farms
			Total		
Farm assets:					
1978	Mil. dol.	218,512	278,096	216,357	712,965
2000	do.	273,238	292,027	1,062,600	1,627,865
Debt/asset ratio:					
1978	Percent	9.5	17.8	22.7	16.7
2000	do.	6.3	17.0	26.0	21.1
Farm debt:					
1978	Mil. dol.	20,660	49,468	49,145	119,273
2000	do.	17,214	49,645	276,276	343,135
Equity:					
1978	Mil. dol.	197,852	228,628	167,212	593,692
2000	do.	256,024	242,382	786,324	1,284,730
Distribution of equity:					
1978	Percent	33.3	38.5	28.2	100.0
2000	do.	19.9	18.9	61.2	100.0
			Per farm		
Farm assets:					
1978	1,000 dol.	123.3	390.0	1,157	266.8
2000	do.	307.4	9,701.9	1,894.1	930.2
Farm debt:					
1978	1,000 dol.	11.7	69.4	262.8	446.6
2000	do.	19.4	164.9	492.5	196.1
Farm equity:					
1978	1,000 dol.	111.7	320.7	894.2	222.2
2000	do.	288.0	805.3	1,401.6	734.1

in the 1964-74 period to 284,000 during the 1984-2004 period, a 40-percent decline in entries.

Since only a few large farming operations will be required to produce the total farm output, many of the younger entries will be on small, part-time farms, and will depend primarily on nonfarm income sources. Expectations of nonfarm income will likely encourage young people associated with what are now marginal or inadequate size farms to choose nonfarm occupations. Therefore, farm numbers will continue to decline as fewer young people enter farming to replace older operators who leave farming.

The replacement rate of young for old operators has been considerably higher for larger farms with sales exceeding $100,000 (table 11). But since there were so many more small farms, 90 percent of the entries from 1964 to 1974 were on farms with sales less than $100,000. By 2000, however, only about half of the entries will be on such smaller farms.

Many of the small farms of retiring farm operators will be consolidated into existing farms, increasing the proportion of large farms. These large farms will require significant amounts of capital. Therefore, the farming opportunities will be limited to a few entries on larger farms. Many of the younger persons entering farming will probably do so on established farms as partners or shareholders with other family members.

Table 10--U.S. farm operator age distribution

Age	1974	1984	1994	2004
	Percent			
Less than 25 years	2.2	2.0	1.8	2.1
25 to 34 years	10.9	13.5	11.0	11.2
35 to 44 years	17.8	19.4	24.5	21.2
45 to 54 years	25.3	22.0	23.5	28.2
55 to 64 years	25.3	24.1	20.6	21.6
65 years and older	18.5	19.0	18.6	15.6
Total	100.0	100.0	100.0	100.0
	Years			
Estimated average age 1/	51.9	51.2	50.8	50.3

1/ The weighted average was calculated from the age distribution by multiplying the weighting factor (the fraction of the farmers in each age group) by the midpoint of each age group. For the youngest age group, the assumed midpoint was 22; for the oldest age group, the assumed midpoint was 71.

Source: Adjusted 1974 Census of Agriculture and age cohort projections.

Tenure of Farm Operators

Tenure patterns in farming have changed. Part-owner operators have increased as a percentage of all farmers. The proportion of full owners has declined only slightly, while the percentage of tenant-operated farms has declined significantly.

The proportion of tenants in each sales class and for all farms decreased from 1969 to 1974, reflecting farmers' long-held desire to acquire farmland and the ability to do so. But at the same time, the proportion of full owners declined only slightly. In 1974, 62 percent of farms were classified as full owners, 27 percent as part owners, and 11 percent as tenants. Full owners mostly dominated in farms with sales of less than $20,000 (73.4 percent), and accounted for less than one-third of the farms with sales of more than $100,000. By contrast, part owners were the majority in farms with sales of more than $100,000--accounting for nearly 60 percent (table 12).

This trend in resource ownership structure is projected to continue into the future. Part owners are likely to account for more than one-third of all farms, while the share of tenants will decline from 11 percent in 1974 to 7 percent in 2000. The share of full owners is likely to remain the same. Full owners will be concentrated mostly in small farms and will account for only 16 percent of

Table 11--Farm operator replacement rates

Item	1964-74	1974-84	1984-94	1994-2004
		Percent		
Replacement rate on farms with sales of: 1/				
$100,000 or more	296	299	293	145
less than $100,000	44	47	42	32
Total	51	56	63	53
		Thousands		
Net entry of operators under 35 years	475	452	405	284
Net exit of operators over 55 years	930	811	650	537

1/ Percentage of exiting operators over 55 years of age replaced in the following decade by entering operators under 35 years at the beginning of the decade.

Source: Adjusted 1974 Census of Agriculture and Projection. See text for details.

farms with sales of more than $100,000. Part owners, on the other hand, will account for about 72 percent of farms with sales of more than $100,000.

Ownership and use of farmland, therefore, will be separated more than is the case now. Farmers will be more likely to rent additional farmland to enlarge their farming operations.

Table 12--Tenure structure by sales class

Item	Less than $20,000	$20,000 to $99,999	$100,000 and over	All farms
	Percent			
Full owners:				
1964	61.8	31.5	34.2	57.9
1969	69.4	35.1	35.3	62.5
1974	74.3	39.3	29.3	61.5
2000	93.0	59.0	16.0	63.0
Part owners:				
1964	21.7	50.3	51.6	24.9
1969	26.9	47.8	51.4	24.6
1974	16.6	44.8	57.2	27.2
2000	4.0	28.0	72.0	30.0
Tenants:				
1964	16.5	18.1	14.1	17.2
1969	17.1	17.1	13.3	12.9
1974	9.1	15.9	13.5	11.3
2000	3.0	12.0	12.0	7.0

TREND EXTRAPOLATION

This chapter describes the projections obtained from simple extrapolations of trends, and the adjustment of the census data to take account of overenumeration and underenumeration. Again, the central question is: If we assume that the current trends are going to continue into the future, what will the structure of agriculture likely be by the year 2000?

Technical Overview

The functional specification for projecting the number of farms in each acre size and sales class was selected on the basis of the R^2 (coefficient of determination) goodness-of-fit criterion, consistency, reasonableness in comparison to the past trend, and, to some degree, our own subjective judgment. To illustrate, a linear trend equation was rejected because: (1) the linear specification frequently projected a much faster rate of decline in farm numbers than one would normally expect. In fact, a linear equation will project the number of farms in the 100-219 acres class to completely disappear by the late 1990's and to be negative in the year 2000; and (2) this form did not generally yield a higher R^2 than a semilog specification, the form eventually selected. Conversely, a polynomial specification was rejected for the opposite reason--it frequently projected trend reversal. Instead of a decline in the number of farms in the 1-to-99-acre size class, it projected an increasing trend into the future.

This left a choice between the log-linear and the semilog forms. The semilog form was chosen because it generally gave a better fit in terms of the R^2 criterion, and it produced expected results better than the log-linear form. For example, the number of farms in the 1-to-99-acre size group historically had declined at a high rate--311,000 farms between 1959 and 1964 and 133,000 between 1969 and 1974. If this trend continues, one would reasonably expect the number of farms in this size group to decline from the 1.36 million in 1974 to about 1.2 million in 1980. Yet, the log-linear specification would project virtually no decline. For similar reasons, we chose the semilog form to project the number for sales classes of less than $20,000, and the log-linear form for sales classes of more than $20,000.

Data Adjustments

The data used throughout this study came primarily from the 1974 Census of Agriculture and earlier censuses; data from other sources are specifically noted. Because of incomplete counting in the census and the importance of capturing the effects of changes in commodity prices on shifts in farm numbers from one sales class to a higher one, adjustments were made to the data used in this study to account for underenumeration and overcounting, and for the effects of price inflation. No adjustments were made to the data for trend projections because the effects of price inflation were assumed to be captured in the trend equations. However, this adjustment was explicitly made for the Markov process and age cohort projections discussed subsequently.

Prior to 1969, all censuses were conducted by personal interview in a complete canvass of rural areas. In 1969, a mailout-mailback, self-enumerated national census was conducted. The change in survey procedure, along with other factors, contributed to the underenumeration problem, that is, an incomplete farm count, especially for small farms (26). Conversely, overcounting sometimes occurred for large farms.

Without adjustment of the census data to account for underenumeration and occasional overcounting, the number of farms reported differs considerably from another primary data source, namely the Farm Income Statistics of the U.S. Department of Agriculture (23). For example, the Farm Income Statistics reported 2.8 million farms in 1974 while the Census of Agriculture estimated 2.47 million farms, a difference of 330,000 farms. 4/ To avoid confusion and maintain the comparability of the census data with USDA estimates, it was necessary to adjust the census data.

The detailed adjustment process for the 1974 Census of Agriculture data by sales class and acre size is shown in appendix tables 2 and 3. In general, the adjustment process for acres and sales was the same. However, slight differences result from the nature of the census data. Abnormal farms are reported separately by sales class, but are included in the number of farms by acreage. 5/ Since abnormal farms could be expected to respond quite differently from normal farms to factors that cause the changes in farm structure, they were excluded from the numbers for purposes of this study. Adjusted Census of Agriculture data by sales class and by acre size for years 1959, 1964, 1969, and 1974, based on procedures illustrated in appendix tables 2 and 3, are shown in tables 13 and 14.

Projections

The estimated trend equations, based on the adjusted census data in tables 13 and 14, are shown in appendix tables 4 and 5. Projections of the farm numbers by acre and sales size are shown in tables 15 and 16.

Farm numbers by acre size are projected to decline from 2.9 million in 1974 to 2.6 million in 1980 and to 1.7 million in 2000. The simple trend projections show the numbers of farms with less than 1,000 acres to continue declining, while those of 1,000 acres or more to continue increasing. Similarly, the number of farms by sales class is projected to decline from 2.9 million in 1974 to 2.6 million in 1980 and 2.1 million in 2000. As expected, the number of small farms (sales less than $20,000) continues to decline, while the number of big farms increases.

4/ The 1959 Census definition of a farm is used in both data sources and throughout this study (see table 1).

5/ Abnormal farms include institutional farms, experimental and research farms, and Indian reservations. Institutional farms include those operated by hospitals, penitentiaries, schools, grazing associations, government agencies, and others.

Table 13--Census of Agriculture data on number of farms, by sales class, adjusted for underenumeration

Sales class	1959	1964	1969	1974
	1,000 farms			
Less than $2,500	1,896.4	1,657.2	1,417.1	1,100.6
$2,500-$4,999	646.0	473.9	432.8	322.9
$5,000-$9,999	683.8	528.6	410.9	319.5
$10,000-$19,999	496.8	484.1	399.5	326.9
$20,000-$39,999	216.4	266.9	329.8	327.6
$40,000-$99,999	84.5	113.5	168.0	327.5
$100,000-$199,999	14.6	21.8	35.0	99.4
$200,000-$499,999	4.7	8.0	12.4	39.3
$500,000 and over	1.2	2.6	4.0	11.2
All farms	4,044.5	3,556.7	3,209.6	2,874.9

Table 14--Census of Agriculture data on number of farms, by size of farm, adjusted for underenumeration

Size of farm	1959	1964	1969	1974
	1,000 farms			
1-9 acres	301.9	217.8	268.0	244.4
10-49 acres	890.3	760.3	675.8	636.1
50-69 acres	291.6	252.2	210.2	188.9
70-99 acres	452.0	394.8	335.8	287.5
100-139 acres	410.0	350.5	301.5	258.7
140-179 acres	392.8	332.8	284.5	239.8
180-219 acres	234.4	206.5	178.7	151.4
220-259 acres	203.1	177.5	148.2	122.9
260-499 acres	507.4	487.7	438.5	379.3
500-999 acres	214.7	225.1	218.4	210.7
1,000-1,999 acres	84.9	89.8	90.7	93.3
2,000 acres and over	61.2	61.6	59.2	62.0
All farms	4,044.5	3,556.7	3,209.6	2,874.9

It is significant to note that the total number of farms projected by sales class exceeds the total projected by acre size starting in 1985. By 2000, the difference is about 400,000 farms. That difference, to a large extent, can be attributed to the trend projections procedures. For farms in the $20,000-$39,999 sales class, the trend first pointed to an upward shift, then a decline in 1974. The estimated trend equation for this sales class, which has a positive coefficient for the time variable, apparently failed to capture the downturn in 1974. Thus, trend projections by sales class are likely to overestimate the total number of farms and the number in the $20,000-$39,999 sales class.

Table 15--Trend projections of the number of farms, by size of farm

Size of farm	1980	1985	1990	1995	2000
			1,000 farms		
1-99 acres	1,190.4	1,060.8	945.3	842.4	750.6
100-219 acres	558.1	477.7	409.0	350.1	299.7
220-499 acres	456.3	406.0	361.3	321.5	286.1
500-999 acres	212.6	210.5	208.9	207.1	205.3
1,000-1,999 acres	96.3	99.3	102.2	105.3	108.4
2,000 acres and over	60.9	60.9	60.9	60.9	60.8
All farms	2,574.6	2,315.4	2,087.5	1,887.2	1,711.0

Table 16--Trend projections of the number of farms, by sales class

Sales class	1980	1985	1990	1995	2000
			1,000 farms		
Less than $2,500	951.4	795.6	665.3	556.3	456.2
$2,500-$4,999	264.3	212.8	171.3	137.8	110.9
$5,000-$9,999	247.7	192.2	149.2	115.8	89.8
$10,000-$19,999	293.2	253.6	219.5	189.9	164.3
$20,000-$39,999	366.2	388.5	408.5	426.6	443.2
$40,000-$99,999	316.9	373.7	429.6	484.8	539.4
$100,000-$199,999	90.1	113.3	137.4	162.5	188.3
$200,000-$499,999	36.0	46.3	57.2	68.8	81.0
$500,000 and over	11.4	14.9	18.7	22.7	27.0
All farms	2,577.1	2,390.9	2,256.6	2,165.2	2,109.2

NEGATIVE EXPONENTIAL FUNCTIONS

This chapter presents an empirical examination of farm size distribution projections to the year 2000 derived by use of negative exponential functions. The farm size distribution, using this projection method, was found to be stable, that is, no significant shifts occur in the distribution over time. However, the size distribution estimated by negative exponential functions deviates from the actual one in that a relatively large proportion of the number of farms goes to the medium-size and large farms (200 acres and more), and a rather small percentage goes to the small farms (less than 100 acres).

Technical Overview

Negative exponential functions have been used by Dovring (7, 8, 9), Boxley (1), Ching (3), and Dixon and Sonka (6) to estimate farm size distributions. If the farm size distribution has been stable around a moving average over time, this would suggest that, if the distributions could be adequately reppresented by a functional form, the projections problem would be reduced to that of estimating future average sizes. It would also suggest that the diversity of farm size characteristics of past and present is likely to extend into the future. And finally, it would suggest that causal economic studies could be conducted to explain this underlying stability.

Although farm numbers have been declining rapidly and average size has been increasing substantially, small farms have not disappeared nor been amalgamated into a few large operations. Dovring (8) suggested that processes influencing farm sizes produced distributions that may be characterized by specific functional forms. The relatively constant land base means that changes in farm numbers of a given size require an offsetting change in numbers in other size categories. That is, the land base is a physical constraint on the number of farms of a given size, and the number possible is inversely related to size. Noting the inverse relationship between frequency of occurrence and farm size categories, Dovring suggested the size distribution of farm numbers should resemble the inverse exponential distribution (7, 8, 9).

The general form of exponential function is e^x where e is the irrational number 2.71828... and x is the manifest variable. The inverse exponential function (e^{-x}) may represent a decumulative size distribution written as:

$$y = y_0 e^{-Bx} \qquad (1)$$

where y is the percentage of farms remaining above a given size limit, x. The size limits can be and are expressed as fractions or multiples of average size in this study, and when $x = 0$, $e^{-Bx} = 1$. The function monotonically decreases asymptotically to zero as x increases. When $Bx = 10$, $e^{-Bx} = .005$ of 1 percent.

Boxley (1) utilized a logarithmic (base 10) transformation of equation (1) as follows:

$$\log y = \log y_0 - Bx \log e \qquad (2)$$

In more general terms:

$$\log y = B_o + B_1 x \qquad (3)$$

where $B_o = \log y_o$ and $B_1 = -B \log e$.

The estimated function was forced through the point representing 100 percent of the farms and the smallest fractional size (that is, restricting 100 percent of the farms to lie above the lower limits of the smallest category). Using the logarithmic transformation (base 10) of the data, this is the point with coordinates $(x_1/\overline{x}, 2.0)$, where x_1 is the lower limit of the smallest size category and $\overline{x}$ is the average farm size. This follows, noting that from:

$$\log y = B_o + B_1 x$$

$\log y = 2.0$ when $x = x_1/\overline{x} = x^o$. That is,

$$2.0 = B_o + B_1 x^o$$

$$B_o = 2.0 - B_1 x^o$$

$$\log y = (2.0 - B_1 x^o) + B_1 x$$

$$= 2.0 + B_1 (x - x^o)$$

The last expression is equivalent to $(\log y - 2.0) = B_1 (x - x^o)$, which indicates operations performed on the data prior to estimation. The value of the constant term for the estimated equation is calculated according to the relationship

$$B_o = 2.0 - B_1 x^o$$

This is not a severe restriction and simply results in the estimated distribution reflecting that all farms are 1 acre or larger in size.

Census of Agriculture data (without adjustment for underenumeration) for the years of 1959, 1964, 1969, and 1974 showing farm numbers by acreage categories were used to estimate distribution functions (as described by equation 3 above) for the United States, nine geographic regions, and each of the 50 States. 6/ The equations, estimated by ordinary least squares, for the four census periods and for the periods combined, with related statistics, are shown in table 17 for the United States and the nine regions.

6/ The States in each region were as follows:
New England: Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut
Middle Atlantic: New York, New Jersey, Pennsylvania
East North Central: Ohio, Indiana, Illinois, Michigan, Wisconsin
West North Central: Minnesota, Iowa, Missouri, North Dakota, South Dakota, Nebraska, Kansas
South Atlantic: Delaware, Maryland, Virginia, West Virginia, North Carolina, South Carolina, Georgia, Florida
East South Central: Kentucky, Tennessee, Alabama, Mississippi
West South Central: Arkansas, Louisiana, Oklahoma, Texas
Mountain: Montana, Idaho, Wyoming, Colorado, New Mexico, Arizona, Utah, Nevada
Pacific: Washington, Oregon, California, Alaska, Hawaii

Table 17--Estimated size distribution function, United States and regions

Region	Year	Intercept	Slope	Coefficient standard error	R^2	F statistic
United States	1959	2.00107	-0.3260	0.0411	0.913	
	1964	2.00101	-.3554	.0426	.921	
	1969	2.00096	-.3754	.0418	.931	0.405
	1974	2.00092	-.3844	.0431	.930	
	1959-74	2.00097	-.3549	.0203	.919	
New England	1959	2.00155	-.2810	.0241	.950	
	1964	2.00145	-.2684	.0246	.952	
	1969	2.00152	-.2914	.0219	.967	.364
	1974	2.00144	-.2763	.0224	.962	
	1959-74	2.00147	-.2721	.0113	.956	
Middle Atlantic	1959	2.00287	-.2524	.0268	.937	
	1964	2.00181	-.2735	.9261	.948	
	1969	2.00176	-.2868	.0255	.955	.352
	1974	2.00165	-.2773	.0236	.958	
	1959-74	2.00175	-.2704	.0124	.947	
East North Central	1959	2.00200	-.3096	.0272	.966	
	1964	2.00185	-.3209	.0254	.964	
	1969	2.00172	-.3171	.0232	.969	.090
	1974	2.00158	-.3030	.0198	.975	
	1969-74	2.00780	-.3130	.0116	.964	
West North Central	1959	2.00098	-.3644	.0282	.965	
	1964	2.00094	-.3799	.0277	.969	
	1969	2.00089	-.3904	.0261	.974	.213
	1974	2.00085	-.3896	.0263	.973	
	1959-74	2.00091	-.3794	.0130	.969	
South Atlantic	1959	2.00142	-.1993	.0277	.896	
	1964	2.00142	-.1993	.0292	.902	
	1969	2.00127	-.2337	.0291	.915	.364
	1974	2.00122	-.2348	.0298	.912	
	1959-74	2.00128	-.2176	.0139	.901	
East South Central	1959	2.00150	-.1821	.0251	.897	
	1964	2.00141	-.1944	.0260	.903	
	1969	2.00137	-.2119	.0261	.916	.351
	1974	2.00130	-.2138	.0266	.915	
	1959-74	2.00137	-.1975	.0124	.903	
West South Central	1959	2.00093	-.3901	.0450	.926	
	1964	2.00088	-.4138	.0446	.935	
	1969	2.00084	-.4299	.0406	.949	.282
	1974	2.00080	-.4434	.0440	.944	
	1959-74	2.00085	-.4152	.0210	.935	
Mountain	1959	2.00049	-.8717	.1063	.918	
	1964	2.00046	-.9228	.1121	.919	
	1969	2.00044	-.9487	.1141	.920	.1311
	1974	2.00045	-.9611	.1277	.904	
	1959-74	2.00046	-.9205	.0544	.914	
Pacific	1959	2.00090	-.3601	.0629	.845	
	1964	2.00085	-.4046	.0704	.846	
	1969	2.00082	-.4221	.0726	.849	.2131
	1974	2.00082	-.4253	.0760	.839	
	1959-74	2.00089	-.3973	.0333	.841	

Few of the regions or States have size distributions that conform exactly to the theoretical negative exponential distribution. This is as expected, since the distribution for most States reflects unique characteristics of the State, such as geographic conditions, types of agriculture, and institutional constraints (for example, large number of small tobacco farms in North Carolina). 7/ It is also expected that long-established, traditional farming areas (with few physical, economic, or institutional constraints) which have undergone fragmentation and reconsolidation of farming units from original settlement patterns would tend to more nearly approximate the inverse exponential distribution.

While the usefulness of estimated equations of this form for projection depends upon the magnitude of deviation from the theoretical distributions, it is also dependent upon the stability of the farm size distribution over time. To determine statistically the stability of the estimated equations, an analysis of the covariance was conducted (3, 4). This involves comparison of the sum of squared residuals from the individual equations and the equation estimated for all groups. The hypothesis tested is that the data used in estimating the parameters of each equation belong to the same regression equation, that is, the data are subsamples of the same population--no significant shifts occur in the distribution over time. The F ratio calculated was expressed as:

$$F = \frac{(A - B - C - D - E) / P(k - 1)}{(B + C + D + E) / (n_1 + n_2 + n_3 + n_4 - 4P)}$$

Where n_i = the number of observations (7) ($i = 1, \ldots, 4$)
p = number of parameters estimated (1 - slope)
k = number of classes (4 - 1959, 1964, 1969, 1974)
A = total group sum of squares of $n_1 + n_2 + n_3 + n_4$ observations with $n_1 + n_2 + n_3 + n_4 - P$ degrees of freedom

B, C, D, E, = individual group sum of squares on n_i deviations of the dependent variable from the regression estimated by n_i observations with $n_i - P$ degrees of freedom.

A comparison of the calculated F (table 17) with tabular F at the 0.05 level of significance indicates the null hypothesis is rejected for only one State, Rhode Island, in the New England region. Thus, the distributions appear stable over time and, if adequately portrayed by the estimated equations, projections may be made with some confidence.

Projections

To maintain the consistency of our data series for projection purposes, it was necessary for us to adjust the Census of Agriculture data for underenumeration and reestimate the negative exponential functions for the United States by using the adjusted census data, as shown in table 2.

7/ For further discussion of why deviations occur, see Dovring (7).

Acreage Distributions

Based on the combined and adjusted 1969 and 1974 census data, the following negative exponential function was estimated:

$$\ln y - 2.0 = \underset{(-13.30)}{-0.4160} \left[\frac{x_i - 1.0}{\bar{x}}\right] \qquad R^2 = 0.885 \qquad (4)$$

where: y = percentage of farms lying above a size limit, x_i,
x_i = the lower size class limit in acres,
$\bar{x}$ = average farm size in acres, and
R^2 = the coefficient of determination.

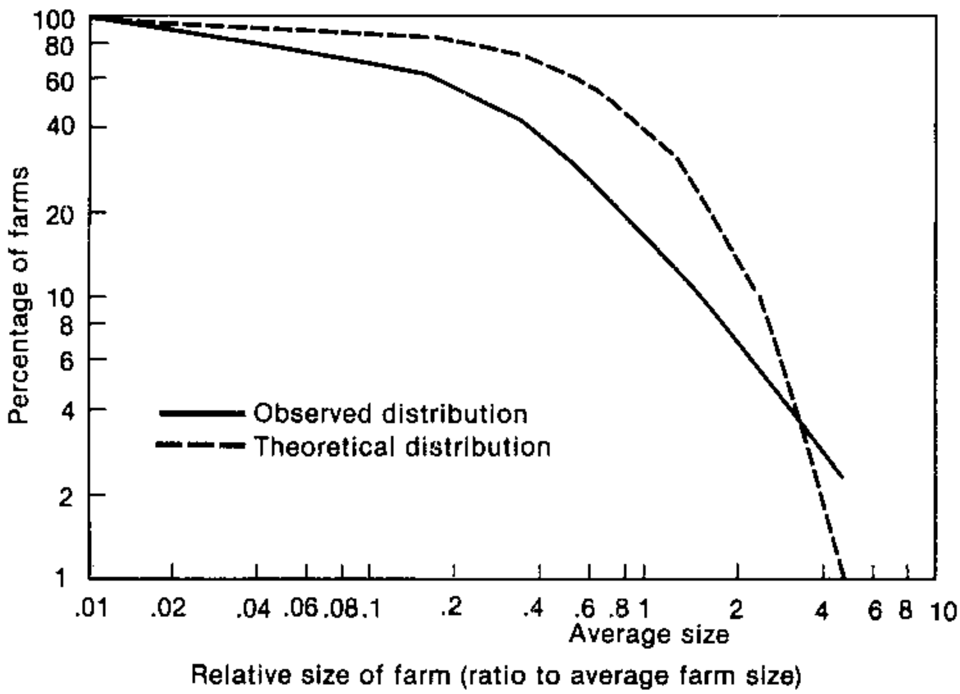
The slope of the function is -0.4160, and the t ratio is shown in parentheses. After calculating the intercept term, the estimated equation can also be written:

$$\ln y = 2.0011 - 0.4160\ x_i/\bar{x} \qquad (5)$$

The intercept term was estimated by using the average farm sizes from 1969 and 1974 census data, after adjusting both land in farms and number of farms for underenumeration (fig. 5). A test for structural change between the two census years again indicated that the hypothesis of no structural change cannot be rejected.

Figure 5

Negative Exponential Curves of the Acreage Distribution, 1974



To the extent that size distribution around a moving average is stable over time, the information required for projecting future farm size distributions is minimal--the projected land in farms and average farm size in acreage distributions, and the projected total sales receipts and average sales receipts in sales distributions. Strictly speaking, however, the rationale for using the negative exponential function is not as strong for size distributions defined by sales. Thus, caution is advised in use of these equations for obtaining precise projections of sales distribution. Nevertheless, for comparison purposes and to maintain consistency throughout this report, sales distributions and their projections are also projected in this section.

Projections of acreage distributions to 2000 were obtained from the estimated equations by dividing the trend average farm size into the lower limits of each of the size categories to obtain new x variable values and the constant term, calculated as described previously. The resulting values are used to obtain the projected decumulative distribution, and the percentage of farms in each size category is found by subtracting each category from the previous one. Projected annual mean sizes were obtained from a linear time trend equation estimated from data for the 1957-77 period. The estimated equation is:

$$M = 363.39 + \underset{(0.20)}{3.02}\, T \qquad R^2 = 0.96 \qquad (6)$$

where M is mean size in acres, T is the time variable (1957 = 1.0, . . .), and the value in parentheses is the standard error of the estimate.

While the above information is sufficient to project future farm size distributions, projections of total number of farms require additional information on expected land in farms in the future. Land in farms was fitted by a linear trend equation based on census data (adjusted for undercoverage) for the years of 1959, 1964, and 1974. The estimated equation is:

$$L = 1233.80 - \underset{(0.13)}{8.16}\, T \qquad R^2 = 0.971 \qquad (7)$$

where L is land in farms and T is the time variable (1959= 1, 1964 = 6, etc.). Total number of farms is projected by dividing the projected average farm size into land in farms.

As expected, the number of farms was projected to continue to decline; a decrease from the actual 2.9 million farms in 1974 to 1.8 million farms in 2000 (table 18). The general pattern of decline in farm numbers is similar to that projected by historical trends reported in the previous section. However, the rate of decline after 1980 slows. During the 1974 to 2000 period, the negative exponential functions projected farm numbers to decrease at an annual average rate of 1.8 percent. Farms less than 220 acres in size show a continued decline in numbers, especially farms of less than 50 acres in size. The projected size distributions in the 220 to 2,000-acre range, although generally continuing a declining trend, present a discontinuity to recent trends: Instead of projecting smaller farm numbers in 1980 than that in 1974, the numbers are projected to increase. This discontinuity becomes more obvious in the 220 to 2,000-acre range. On the other hand, the numbers projected for the size class of over 2,000 acres present the opposite kind of discontinuity, even though the increasing trend is maintained.

Table 18--Projected number of U.S. farms, by size of farm, negative exponential function

Size of farm	1974 (actual)		1980		1985		1990		1995		2000	
	Thousands	Percent	Thousands	Percent	Thousands	Percent	Thousands	Percent	Thousands	Percent	Thousands	Percent
1-9 acres	244.4	8.5	48.6	2.0	43.6	1.9	39.2	1.9	35.2	1.8	31.7	1.7
10-49 acres	636.1	22.1	204.5	8.3	184.0	8.1	165.6	7.8	149.1	7.6	134.3	7.4
50-69 acres	188.9	6.6	95.7	3.9	86.3	3.8	77.8	3.7	70.2	3.6	63.3	3.5
70-99 acres	287.5	10.0	135.8	5.5	122.6	5.4	110.8	5.2	100.2	5.1	90.5	5.0
100-139 acres	258.7	9.0	167.5	6.8	151.8	6.6	137.5	6.5	124.5	6.3	112.2	6.2
140-179 acres	239.8	8.3	153.3	6.2	139.3	6.1	126.5	6.0	114.9	5.8	104.3	5.7
180-219 acres	151.4	5.3	140.3	5.7	127.9	5.6	116.5	5.5	106.0	5.4	96.5	5.3
220-259 acres	122.9	4.3	128.3	5.2	117.3	5.1	107.2	5.1	97.9	5.0	89.3	4.9
260-499 acres	379.3	13.2	571.3	23.2	527.3	23.1	486.1	22.9	447.6	22.7	411.5	22.5
500-999 acres	210.7	7.3	544.9	22.2	515.7	22.6	486.7	22.9	458.2	23.3	430.2	23.6
1,000-1,999 acres	93.3	3.2	239.2	9.7	237.2	10.4	234.0	11.0	229.6	11.7	224.3	12.4
2,000 acres and over	62.0	2.2	29.3	1.2	31.6	1.4	33.7	1.6	35.7	1.8	37.4	2.1
All farms	2,874.9	100.0	2,458.8	100.0	2,284.5	100.0	2,121.7	100.0	1,969.1	100.0	1,825.9	100.0

Sales Distributions

Based on the 1974 adjusted census data, the equation below does not estimate the sales class distributions as well as the acreage distributions:

$$\ln y - 2.0 = \underset{(-6.627)}{-0.18961}\left[\frac{x_i - 1.0}{\bar{x}}\right] \qquad R^2 = 0.846 \qquad (8)$$

where: y = percentage of farms that lie above a size limit x_1,
x_1 = the lower size class limit in sales receipts,
$\bar{x}$ = the average sales receipts per farm, and
R^2 = the coefficient of determination.

The slope of the function is -0.18961, and the t ratio is shown in parentheses. After calculating the intercept term, the estimated equation for 1974 sales distribution can be written alternatively as:

$$\ln y = 2.00029 - 0.18961\, x_1/\bar{x} \qquad (9)$$

The constant term was estimated by using the average sales receipts per farm ($33,077) in 1974.

It is necessary to have projected average sales per farm to project the future sales distribution. A linear trend equation for this purpose was estimated for the period 1970-77:

$$S_a = \underset{(0.259)}{2152.47} + \underset{(2.815)}{4645.33}\, T \qquad R^2 = 0.569 \qquad (10)$$

where: S_a = average sales receipts per farm,
T = time (1970 = 1.0, 1971 = 2.0, etc.),

and the t ratios are in parentheses. In addition, total sales receipts are needed so that the number of all farms can be projected. Another linear trend equation for this purpose was estimated:

$$S_t = \underset{(6.878)}{44{,}998.3} + \underset{(5.637)}{7{,}303.13}\, T \qquad R^2 = 0.841 \qquad (11)$$

where S_t is total sales receipts, and the other values are as defined above. Projected total farm numbers again continue to decline, with the pattern similar to that of acreage distributions (table 19).

The projected sales distributions, however, appear to depart from the historical trends in several important aspects. First, the negative exponential function projects far too many farms with sales of more than $100,000. Second, small farms (sales less than $20,000) are projected to disappear at a rapid rate--a decline from 72 percent of the total number of farms in 1974 to 6 percent in 2000. Third, the number of farms in the $40,000-to-$99,999 sales class is projected to be smaller in 2000 than the number in 1974.

Table 19--Projected number of U.S. farms, by sales class, negative exponential functions

Sales class	Actual 1974		1980		1985	
	Thousands	Percent	Thousands	Percent	Thousands	Percent
Less than $2,500	1,100.6	38.3	46.8	2.0	29.0	1.4
$2,500-4,999	322.9	11.2	46.8	2.0	33.4	1.6
$5,000-9,999	319.5	11.1	90.6	3.9	55.9	2.6
$10,000-19,999	326.9	11.4	170.9	7.3	111.7	5.3
$20,000-39,999	327.6	11.4	302.2	12.8	201.3	9.5
$40,000-99,999	327.5	11.4	659.0	28.0	489.5	23.1
$100,000-199,999	99.4	3.5	580.4	24.7	520.0	24.6
$200,000-499,999	39.3	1.4	417.8	17.8	553.8	26.2
$500,000 and over	11.2	.4	39.1	1.7	121.7	5.8
All farms	2,874.9	100.0	2,353.6	100.0	2,116.3	100.0
	1990		1995		2000	
	Thousands	Percent	Thousands	Percent	Thousands	Percent
Less than $2,500	22.7	1.1	17.6	.9	12.8	.7
$2,500-4,999	22.7	1.1	17.4	.9	12.6	.7
$5,000-9,999	39.8	2.0	34.4	1.8	29.3	1.6
$10,000-19,999	81.6	4.1	62.5	3.3	53.1	2.9
$20,000-39,999	152.6	7.7	122.5	6.4	101.6	5.5
$40,000-99,999	385.6	19.4	316.2	16.2	270.9	14.6
$100,000-199,999	455.2	22.9	402.4	21.1	353.7	19.1
$200,000-499,999	606.8	30.5	614.3	32.2	606.1	32.6
$500,000 and over	222.6	11.2	323.7	16.9	416.7	22.4
All farms	1,989.5	100.0	1,910.7	100.0	1,856.9	100.0

MARKOV PROCESS

This chapter reviews the use of Markov processes for projecting farm number and size distributions, describes the process of adjusting the census data for the effects of price inflation, and presents projections to the year 2000. As a result of an 80-percent increase in prices received by farmers between 1969 and 1974, about 90 percent of the apparent increase in the numbers of farms with sales of $100,000 and more is attributed to the effects of price inflation. Of the projected 1.9 million farms in 2000, small farms (less than $20,000) will constitute 50 percent, a decrease from the 72 percent in 1974. By contrast, large farms (sales of $100,000 and more) will constitute 33 percent, an increase from 5 percent in 1974.

Technical Overview

Markov processes have been used to estimate the number and size distribution of firms for a number of industries, including agriculture. 8/ These applications have often used modifications or variants of a Markov process. Many of the modifications are concerned with the estimation of a transition matrix (that is, a description of how firms move among size categories over time) and are necessitated by limited data describing the movement of firms from one time period to another (for example, see 16, 18, 20).

The Markov chain process assumes that a population can be classified into various groups (S_1, S_2, ..., S_n) and that movements between states over time can be regarded as a stochastic process that can be quantified by probabilities. The states must be defined so that an individual can only be in one state at any point in time. A transition occurs when an individual shifts from one state to another.

A crucial step in the use of Markov processes is estimation of the transition probability--the probability of movement from one state to another in a specified time period. The transition probabilities, P_{ij}, can be expressed in the form of transition matrix, P:

$$P = \begin{array}{c} \\ S_1 \\ S_2 \\ \vdots \\ S_n \end{array} \begin{array}{c} \underline{S_1} \quad\quad \underline{S_2} \quad \cdots \quad \underline{S_n} \\ \begin{bmatrix} P_{11} & P_{12} & \cdots & P_{1n} \\ P_{21} & P_{22} & \cdots & P_{2n} \\ \vdots & \vdots & & \vdots \\ P_{n1} & P_{n2} & \cdots & P_{nn} \end{bmatrix} \end{array}$$

where: $\sum_j P_{ij} = 1.0$ and $P_{ij} \geq 0$, for all i and j.

The elements of P (the P_{ij}) indicate the probability of moving from state S_i to S_j in the next period. Since the elements of the matrix are nonnegative and the sum of the elements in any row is unity, each row of the matrix is a probability

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8/ Illustrative studies include (5, 12, 16, 20).

vector, and P is a stochastic matrix. The matrix, P, in combination with an initial starting state completely defines a Markov chain process.

A chain is irreducible if all states are required to be accessible, that is, there is a nonzero probability of moving from state i to state j in a finite number of time periods. A sufficient condition for the transition matrix P to be irreducible is that some power of the matrix have only positive components.

Traditional Markov analysis projects future farm numbers by multiplying the row vector of farm numbers in the base period by the transition matrix which was constructed from actual farm numbers in the past. This analytical approach implicitly assumes that changes in prices received by farmers can be ignored or that farm product prices change little between periods. Historicially, that was a valid assumption--the index of prices received by farmers has remained relatively stable, increasing by less than 1 percent annually between 1954 and 1969. However, a changing economic environment resulted in a nearly 80-percent increase in the prices received by farmers between 1969 and 1974, thus requiring that explicit attention be given to product prices.

Data Adjustments

The general approach in this study to adjust the census data for the effects of price inflation explicitly differentiates and quantifies the changes in farm numbers into two components: (1) changes due to price inflation; and (2) changes due to "real" factors such as technological change, economies of size, farm commodity programs, production and market instabilities, land enlargement, and the like.

The percentage increase in the index of prices received by farmers is used to quantify the shift from current (1974) to a constant (1969) dollar sales distribution of farm numbers. The sales distribution was approximated by a decumulative polynomial function with both sales and farm numbers expressed in logarithmic values. That is:

$$FN(s) = \alpha \exp \sum_{n=1}^{N} \beta_n (\ln s)^n$$

where $FN(s)$ = cumulative farm numbers that produce sales receipts in excess of s,

s = sales receipts,

n = degree of the polynomial function, and

α, β_n = parameters of the distribution.

This distribution function differs from the traditional Pareto distribution of income and wealth in that a negatively sloped <u>nonlinear</u> functional relation, instead of linear, is assumed to exist between the cumulative number of farms and the sales receipts, with both variables expressed in natural logarithmic values. 9/ The nonlinear specification gives a closer fit to observed data than the linear function.

The 80-percent increase in the index of prices received by farmers between 1969 and 1974 implies that $1 worth of agricultural products sold in 1974 carried a price tag of $0.56 in 1969. The cumulative distribution of farm numbers by sales class in 1974, therefore, was transformed into a comparable sales distribution in 1969 constant dollars by multiplying 0.56 by the sales value associated with each observation on the current dollar sales distribution. 10/ Based on the estimated polynomial functions of the two sales distributions, predicted cumulative distributions of 1974 farm numbers (both in 1974 current dollars and 1969 constant dollars) are shown in figure 6 and columns 5 and 6 in

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9/ The Pareto law of income distribution asserts that "the logarithm of the percentage of units with an income in excess of some value is a negatively sloped linear function of the logarithm of that value" (15). Mathematically, it has the form:

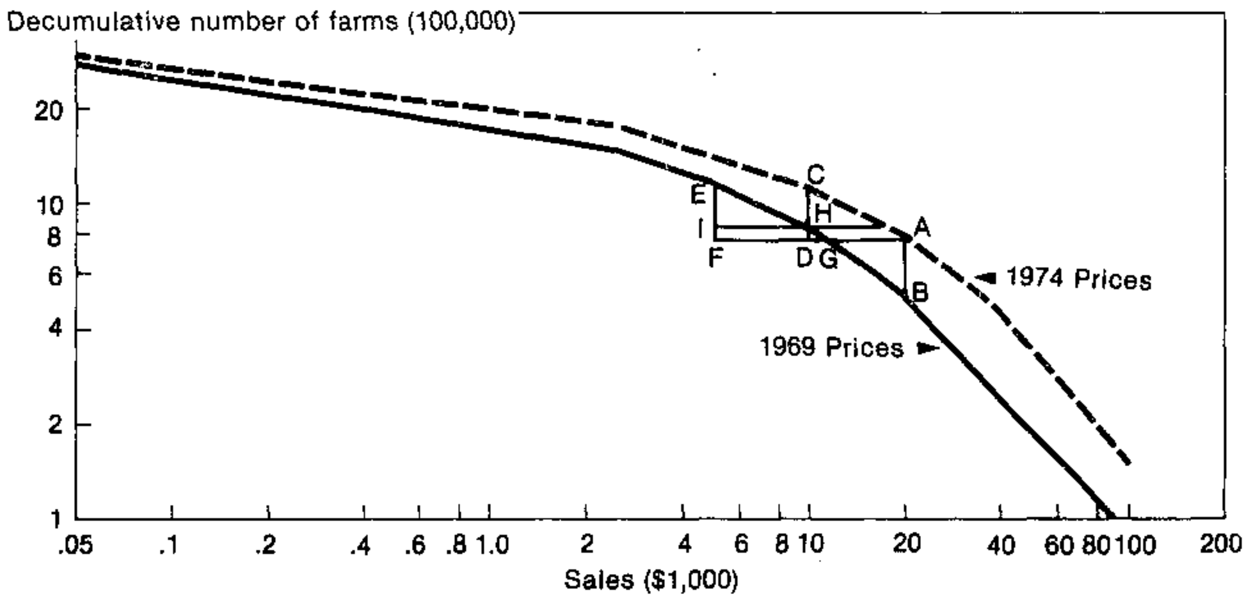
$$P(y) = A\ Y^{-\alpha}$$

$P(y)$ = percentage of units with income in excess of Y,
Y = income level
A, α = parameters of the distribution

10/ This approach implicitly assumes that farms within a sales class are uniformly distributed.

Figure 6

1974 Farm Numbers in 1974 and 1969 Farm Prices



Decumulative means that the distance along the y-axis between points A and C, for example, is the number of farms in the sales class of $10,000 to $19,999.

table 20. For example, while there were about 800,000 farms with sales of $20,000 and more in 1974 (point A in fig. 6), the number of farms dropped to about 500,000 when the sales were expressed in 1969 dollars (point B in fig. 6).

The next step is to figure out the shifts in farm numbers for each sales class through this deflationary process. That is, to determine the numbers of farms that remain in the same sales class and those that move to the lower sales classes. For example, the 327,000 farms with sales of $10,000 to $19,999 in 1974 would have had sales ranging from $5,600 to $11,200 if they had not had an 80-percent increase in prices received due to inflation. In other words, the same 327,000 farms which are measured by the vertical distance CD for segment CA in the current dollar distribution, now can be measured by the vertical distance EF for segment EG in the 1969 constant dollar distribution (fig. 6).

It is clear that distance DH (60,900 farms) measures the number of farms with sales of $10,000 to $19,999 that remain in the same size class after the deflation, a difference between point H (853,600 farms) and point A (792,700 farms). In the meantime, distance CH or EI (265,400 farms) measures the number of farms that move to the lower sales class ($5,000 to $9,999), a difference between point C (1,118,900 farms) and point H. Thus, the 80-percent increase in prices received by farmers due to inflation is estimated to have moved 265,400 farms up statistically from the sales class of $5,000 to $9,999 to the next higher sales class ($10,000 to $19,999), a gain in the number of farms with sales of $10,000 to $19,999 (column 8 in table 16). Repeating the same deflationary process for farms in the next higher sales class ($20,000 to $39,999), we estimated that the price inflation moved 281,200 farms up from the sales class of $10,000 to $19,999 to the next higher sales class ($20,000 to $39,999), a loss in the number of farms with sales of $10,000 to $19,999 (column 9 in table 20). Therefore, the 80-percent increase in prices received by farmers due to inflation had the net effect of reducing the number of farms in the sales class of $10,000 to $19,999 by 15,800 farms. Table 20 shows that the number of farms in this sales class declined by 72,600 from 1969 to 1974. The preceding interpretation of that decline, however, tells us that about 22 percent of it (15,800 farms) was attributed to the price inflation and the remainder (56,800 farms) was due to other "real" factors.

Performing the same analysis for each sales class, we obtained a gain-loss array of the changes in farm numbers due to price inflation as shown in table 20. In general, price inflation has a net effect of reducing the number of small farms and increasing the number of large farms. As a result of an 80-percent increase in prices received by farmers between 1969 and 1974, about 90 percent of the apparent increase in the numbers of farms with sales of $100,000 and more is attributed to the effects of price inflation. Farms with sales of $100,000 and more increased by 98,500, but 88,200 of those were pushed into the higher sales classes because of the price inflation.

Projections

The Markov process, as employed in this study, enables projecting the future number of farms by acreage by multiplying the transition probability matrix by the row vector of farm numbers in the base year. The projection proceeds in two steps, however, when sales are used to measure the size of farms. First, a

Table 20--Calculation of change in farm numbers due to price inflation and other factors, by sales, 1969-74

Sales	Farm numbers			Cumulative distribution of 1974 farm numbers 1/		Number of farms retained in class	Change due to inflation					Change due to other factors	1974 farm numbers without price inflation
	1969	1974	Actual change	1969 dollars	1974 dollars		Gain	Loss	Net	Percent gain 2/	Percent loss 3/		
						Thousands							
$500,000 and over	4.03	11.21	7.18	5.73	10.88	5.73	5.15	--	5.15	46	--	2.03	6.06
$200,000-499,999	12.46	39.33	26.87	18.51	48.70	7.63	30.19	5.15	25.04	77	41	1.83	14.29
$100,000-199,999	34.97	99.38	64.41	59.51	147.71	10.81	88.20	30.19	58.01	89	86	6.40	41.37
$40,000-99,999	168.01	327.52	159.51	237.48	456.42	89.42	218.94	88.20	130.74	67	52	28.77	196.78
$20,000-39,999	329.79	327.57	-2.22	511.54	792.72	55.12	281.18	218.94	62.24	86	66	-64.46	265.33
$10,000-19,999	399.52	326.90	-72.62	853.59	1,118.98	60.87	265.39	281.18	-15.79	81	70	-56.83	342.69
$5,000-9,999	410.93	319.47	-91.46	1,173.21	1,408.81	54.23	235.60	265.39	-29.79	74	65	-61.67	342.69
$2,500-4,999	432.80	322.95	-109.85	1,462.89	1,751.64	54.08	288.75	235.60	53.15	89	54	-163.00	269.80
Less than $2,500	1,417.06	1,100.60	-316.46	2,750.00	2,873.13	998.36	123.13	288.75	-165.62	11	20	-150.84	1,266.32
Total	3,209.57	2,874.93	-334.64	--	--	--	--	--	--	--	--	--	2,751.80

1/ These are cumulative farm numbers distributions predicted by a fifth-degree polynomial function with both sales receipts and farm numbers expressed in natural logarithms.
2/ Column 8 divided by column 3.
3/ Column 9 divided by column 2.

-- = Not applicable.

projection is obtained by multiplying the transition probability matrix (which is constructed from constant dollar distributions of farm numbers) by the row vector of farm numbers in the base year. Second, effects of anticipated increase in prices received by farmers on the number of farms in each sales class are then incorporated into the projection results obtained in step one.

In the absence of more detailed data on entry, exit, and farm movement among size classes, we relied on aggregate census data in recent years to construct and approximate the transition probability matrix. The guiding principle in developing this matrix was to select numerical values that minimized the residual sum of squares, computed from the projected and actual number of farms by size class. Analytically, this problem can be solved with a quadratic programming framework (18). This study, however, employed a less formal, trial-and-error iterative procedure and, in part, assumed traditional farm movement patterns underlying the Markov process to construct the transition probability matrix. 11/ Farms were permitted to expand their size or to exit from farming, but not to contract. In addition, we assumed that the number of farms in the largest size class would remain in that category and that any increase in the number of farms in a size class came from the immediately smaller size class. 12/

To illustrate, all the farms of 2,000 acres and more in 1969 (59,167--see table 14) were assumed to remain in the same size category in 1974--they neither ceased operations nor moved to a smaller size class. Thus, the same 59,167 farms were placed in the diagonal element of the farm movement matrix between 1969 and 1974, the cell intersecting row vector A10 and column vector A10 (table 21). The numerical value in row A9 and column A10 is then the estimate of farms (2,827) moving up from size class A9 to A10.

The number of farms lost in the consolidation process in size class A9 (farmland of 1,000 to 1,999 acres) is then estimated as 11,135. Before the consolidation took place, the 2,827 farms that moved up from size class A9 to A10 operated about 3.83 million acres of farmland. By contrast, the same 2,827 farms operated about 18.93 million acres of farmland after the expansion. This implies that about 15.1 million acres of farmland were consolidated from size class A9 to A10 in the process of structural change between 1969 and 1974. Translating the consolidated farmland into the number of farms lost in the consolidation process means that 11,135 farms moved out of farming in size class A9 (15,100,000 / 1,356). Mechanically, this net exit estimate (column A0) can be computed as:

$$11{,}135 = [(6{,}697/1{,}356) - 1] \times 2{,}827$$

The number of farms that remain in size class A9 is then computed as the difference between the 1969 number of farms in size class A9 and the sum of the number of farms that move up to the higher class (A10) and those in the net exit category.

11/ The combined use of the iterative procedure and traditional farm movement assumptions results in a projection error of less than 1 percent.

12/ This is what is known as the 100-0-0 transition pattern as illustrated by Daly, Dempsey, and Cobb (5). This assumption was found to give a better fit to actual data than other alternatives, including 40-40-20 and 60-40-0 patterns.

Continuing this process, we have shown that a number of farm movement matrix elements can be constructed. Starting from the size category of 260 to 499 acres and continuing on to the smallest size class, this process breaks down, however; it begins to yield nonpositive diagonal elements. 13/ A trial-and-error iterative procedure is thus employed to identify the remaining matrix elements that minimize the residual sum of squares, computed from the projected and actual number of farms by size class. The off-diagonal elements, again, reflect the number of farms moving to the upper classes. As a result, the diagonal elements are all positive--with the numerical value ranging from about 82 percent to 93 percent of the number of farms in 1969.

Following the same procedure, we constructed a movement matrix by sales class between 1969 and 1974 (table 22). The transition probability matrices, obtained by dividing the number of farms in the farm movement matrix by the 1969 number of farms in each size class, are shown in tables 23 and 24.

The transition probability matrix is the crux of the Markov process; therefore, its stability over time will contribute to the accuracy of projections. The probabilities were so stable that there were virtually no differences between the two transition matrices, one for the 1969 to 1974 period and another for the 1964 to 1969 period. In this way, the transition probability matrix used for projections actually represents the synthesis of the two periods: 1964 to 1969 and 1969 to 1974.

Acreage Distribution

The number of farms is projected to decline to 2.1 million in 1990 and 1.7 million in 2000. Of the projected 1.7 million farms in 2000, large farms (those with 1,000 acres or more) will account for about 10 percent, an increase from 5 percent in 1974. By contrast, the proportion of small farms (those with less than 220 acres) is projected to remain high, 68 percent as compared to 70 percent in 1974 (table 25).

Historically the number of farms with less than 500 acres has been declining since 1945. Projected acreage distributions based on the Markov process show that this trend is likely to continue into the year 2000. In addition, the decline of the number of farms with 400 to 999 acres, beginning in 1969, is projected to continue. About 90 percent of all farms in 2000 will likely have less than 1,000 acres.

Sales Distribution

The transition probability matrix by sales class was intended to reflect the physical change in farm structure, discounting any effects of price inflation. Thus, multiplying the transition probability matrix by the base period (say 1969) number of farms does not result in the projected number of farms in 1974. Instead, the projection is derived by adding the effects of price infla-

13/ This finding appears to have economic meaning. It could suggest that the farm growth and consolidation process may not start from the very small size classes as is implied in the traditional Markov process. Rather, consolidation may actually begin from a larger, more economically viable size level, such as 500 acres or larger.

Table 21--Farm movement matrix by acreage, 1969-74: 100-0-0 movement assumption

Size of farm	1974 average farm size	A_0	A_1	A_2	A_3	A_4	A_5	A_6	A_7	A_8	A_9	A_{10}
	Acres	Numbers of farms										
1-69 acres (A_1)	32	84,257	1/ 1,069,433	335								
70-99 acres (A_2)	82	47,814		2/ 287,137	882							
100-139 acres (A_3)	117	42,923			2/ 257,808	799						
140-179 acres (A_4)	158	44,146				3/ 238,987	1,375					
180-219 acres (A_5)	198	27,270					3/ 150,072	1,315				
220-259 acres (A_6)	238	20,075						4/ 121,536	6,604			
260-499 acres (A_7)	359	40,964							5/ 372,693	24,805		
500-999 acres (A_8)	687	16,055								185,897	16,487	
1,000-1,999 acres (A_9)	1,356	11,135									76,777	2,827
2,000 acres and over (A_{10})	6,697	0										59,167

1/ Computed as 92.7 percent of the number of farms in 1969.
2/ Computed as 85.5 percent of the number of farms in 1969.
3/ Computed as 84.0 percent of the number of farms in 1969.
4/ Computed as 82.0 percent of the number of farms in 1969.
5/ Computed as 85.0 percent of the number of farms in 1969.

Table 22-Farm movement matrix by sales class, 1969-74: 100-0-0 movement assumption

Sales class	S_0	S_1	S_2	S_3	S_4	S_5	S_6	S_7	S_8	S_9
	1,000 farms									
Less than $2,500	147.21	1/ 1,266.85	3.00							
$2,500-4,999	154.33		2/ 266.17	12.30						
$5,000-9,999	50.80			3/ 336.96	23.07					
$10,000-19,999	56.05				4/ 319.62	23.85				
$20,000-39,999	30.32					241.48	57.99			
$40,000-99,999	12.12						138.79	17.10		
$100,000-199,999	4.62							24.27	6.08	
$200,000-499,999	2.16								8.21	2.03
$500,000 and over	0									4.03

1/ 89.4 percent of the number of farms in 1969.
2/ 61.5 percent of the number of farms in 1969.
3/ 82 percent of the number of farms in 1969.
4/ 80 percent of the number of farms in 1969.

Table 23--Farm transition matrix by size of farm, 1969-74: 100-0-0 movement assumption

Size of farm	A_0	A_1	A_2	A_3	A_4	A_5	A_6	A_7	A_8	A_9	A_{10}
	Probabilities										
1-69 acres (A_1)	.073	.927	.0003								
70-99 acres (A_2)	.142		.855	.003							
100-139 acres (A_3)	.142			.855	.003						
140-179 acres (A_4)	.155				.840	.005					
180-219 acres (A_5)	.153					.840	.007				
220-259 acres (A_6)	.135						.820	.045			
260-499 acres (A_7)	.093							.850	.057		
500-999 acres (A_8)	.073								.851	.075	
1,000-1,999 acres (A_9)	.123									.846	.031
2,000 acres and over (A_{10})	0										1.000

Table 24--Farm transition matrix by sales class, 1969-74: 100-0-0 movement assumption

Sales class	S_0	S_1	S_2	S_3	S_4	S_5	S_6	S_7	S_8	S_9
	Probabilities									
Less than \$2,500 (S_1)	0.104	0.894	0.002							
\$2,500-4,999 (S_2)	.357		.615	0.028						
\$5,000-9,999 (S_3)	.124			.820	0.056					
\$10,000-19,999 (S_4)	.140				.800	0.060				
\$20,000-39,999 (S_5)	.092					.732	0.176			
\$40,000-99,999 (S_6)	.072						.826	0.102		
\$100,000-199,999 (S_7)	.132							.694	0.174	
\$200,000-499,999 (S_8)	.174								.662	0.164
\$500,000 and over (S_9)	0									1.000

tion or number of farms to the aforementioned results. This process must also be repeated through the projection periods and we must assume what the rate of future price inflation will be.

In this study, we assumed the following changes in farm prices received by farmers:

Projection period	Percentage increase in prices received by farmers
1974-85	68.2
1985-90	42.0
1990-95	34.0
1995-2000	27.0

These assumptions between 1974 and 1990 are based on the National-Interregional Agricultural Projections (NIRAP) high demand and low supply projections. After 1990, the increasing trend of prices received by farmers (evident since 1972) is assumed to continue (see figure 7).

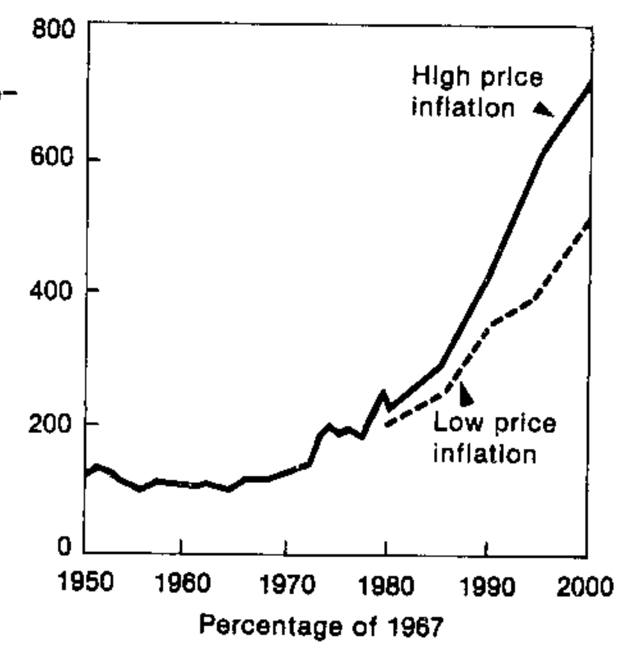
The number of farms is projected to decline to 2.2 million in 1990 and 1.86 million in 2000. The number of small farms (those with sales of less than $20,000) is projected to decline from 72 percent of the total in 1974 to 56 percent in 1990, and 50 percent by the turn of the century. By contrast, the number of farms having sales of over $100,000 is projected to increase from the 5.2 percent in 1974 to 21 percent in 1990, and about 33 percent in 2000 (table 26).

For comparison, another set of projections is shown in table 27 based on the following low price inflation assumptions 14/:

Projection period	Percentage increase in prices
1974-85	32.5
1985-90	24.5
1990-95	27.0
1995-2000	27.4

Figure 7

Actual and Projected Prices Received by Farmers



14/ These assumptions were obtained from the National-Interregional Agricultural Projections (NIRAP) baseline of May 1, 1978.

The main effect of the low price inflation assumptions is to shift the projected number of farms from large sales classes to smaller classes. Under the low price inflation assumption, the number of small farms is projected to decline at only a moderate rate, from 72 percent of the 1974 total to 63 percent in 1990, and to 56 percent in 2000. Similarly, percentage increases in large farms are projected to increase less drastically. The number of farms with sales of over $100,000 is projected to increase to 14 percent of the total in 1990, and to 24 percent in 2000.

Table 25- Projected number of farms, by size of farm, Markov chain analysis

Size of farm	Actual 1974	1980	1985	1990	1995	2000
				1,000 farms		
1-69 acres	1,069.4	991.4	919.0	851.9	789.7	732.1
70-99 acres	287.5	246.1	210.7	180.4	154.5	132.4
100-139 acres	258.7	222.0	190.6	163.6	139.9	121.0
140-179 acres	239.8	202.2	170.5	143.8	121.3	102.3
180-219 acres	151.4	128.4	108.9	92.3	78.3	66.3
220-259 acres	122.9	101.8	84.4	69.9	58.1	48.1
260-499 acres	379.3	327.9	283.3	244.6	211.1	182.0
500-999 acres	210.7	200.9	189.7	177.6	165.1	152.5
1,000-1,999 acres	93.3	94.7	95.2	94.8	93.5	91.5
2,000 acres and over	62.0	64.9	67.8	70.8	73.7	76.6
All farms	2,974.9	2,580.4	2,320.1	2,089.7	1,885.0	1,704.8

Table 26--Projected number of farms, by sales class, Markov process, high price inflation (7.5 percent per year)

Sales class	Actual 1974	1980	1985	1990	1995	2000
			1,000 farms			
Less than $2,500	1,100.6	928.9	855.4	794.7	760.5	639.9
$2,500-$4,999	323.0	185.8	176.1	115.4	82.6	72.3
$5,000-$9,999	319.5	251.0	179.0	141.7	129.4	108.4
$10,000-$19,999	326.9	274.4	210.6	166.5	126.1	108.1
$20,000-$39,999	327.6	269.4	213.7	176.1	123.9	88.3
$40,000-$99,999	327.5	392.7	388.8	338.8	290.8	262.0
$100,000-$199,999	99.4	131.5	184.5	217.9	205.8	167.5
$200,000-$499,999	39.3	69.8	96.1	150.8	187.7	190.1
$500,000-and over	11.2	20.6	49.5	90.3	155.0	225.8
All farms	2,874.9	2,524.1	2,354.0	2,193.2	2,061.8	1,862.4

Table 27--Projected number of farms by sales class: Markov process, low price inflation

Sales Class	1974 Actual	1974 Projection	1980	1985
	1,000 farms			
Less than $2,500	1,100.6	1,101.2	998.0	894.5
$2,500-$4,999	323.0	322.2	202.7	197.3
$5,000-$9,999	319.5	319.3	270.9	233.1
$10,000-$19,999	326.9	326.8	279.0	211.9
$20,000-$39,999	327.6	327.6	260.4	193.9
$40,000-$99,999	327.5	327.6	331.1	371.4
$100,000-$199,999	99.4	99.4	104.0	143.0
$200,000-$499,999	39.3	39.3	44.1	67.0
$500,000 and over				
All farms	2,874.9	2,874.7	2,508.2	2,341.6

Sales Class	1990	1995	2000
	1,000 farms		
Less than $2,500	881.2	865.0	750.0
$2,500-$4,999	135.6	102.0	50.0
$5,000-$9,999	189.4	155.8	140.0
$10,000-$19,999	165.7	124.2	100.0
$20,000-$39,999	147.0	101.9	100.0
$40,000-$99,999	370.2	350.6	275.0
$100,000-$199,999	161.7	178.1	181.5
$200,000-$499,999	90.1	113.2	132.0
$500,000 and over	51.0	83.0	121.5
All farms	2,191.9	2,069.6	1,850.0

AGE COHORT ANALYSIS

This chapter presents an overview of analysis by age cohorts (people born in the same decade), cohort adjustments by size class and projections obtained by this method. The number and sizes of farms change through time as farm operators enter, adjust the size of their operations, and leave agriculture. The life cycle of the farm operator has long been related to the concurrent phases of entry, expansion, and exit from the farm business: (1) young farmers (less than 35 years)--entry and establishment phase; (2) middle-aged farmers (35 to 54 years)--expansion phase; and (3) older farmers (55 and older)--exit, transfer, or close-out phase.

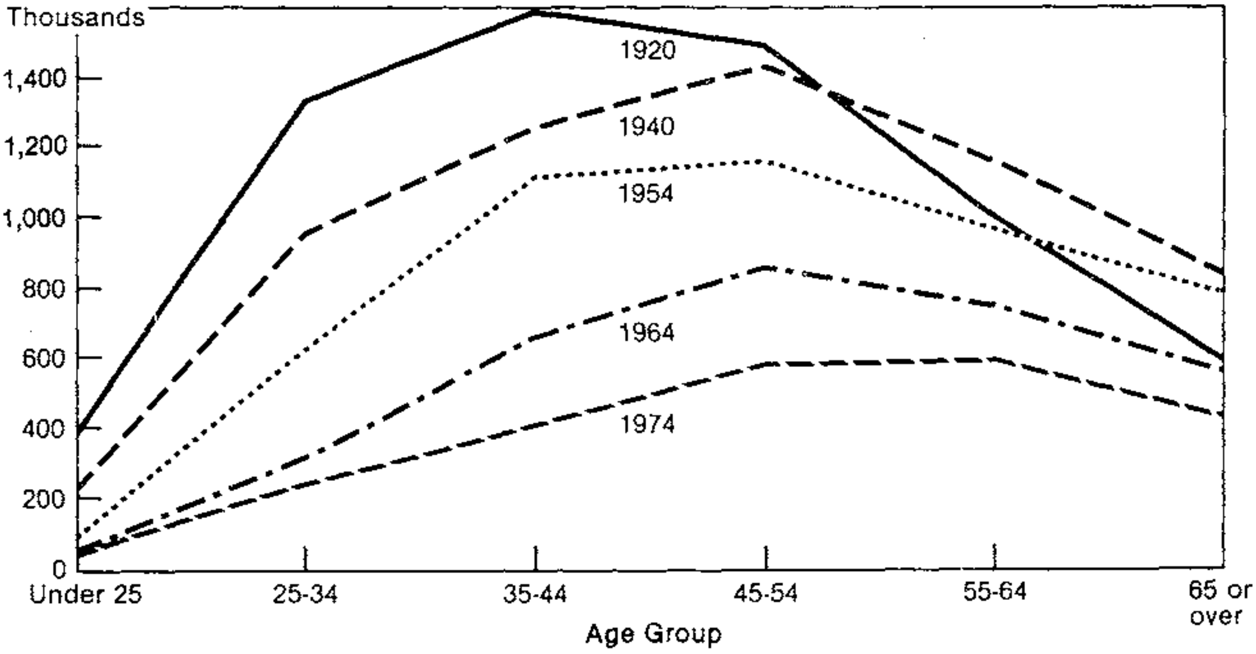
Technical Overview

Figure 8 shows the decreasing number and increasing age of farm operators. The age distribution shifts because the numbers of young persons entering farming are fewer than the numbers of older persons retiring or leaving farming. Also, many older operators continue to farm past the usual retirement age, when they are not replaced by a younger generation. Occupational mobility decreases as farm operators advance in age, further contributing to the shift in age distribution (2, 10, 11, 13) and the long-term adjustment process for farm operator number and farm size.

Age cohorts can be traced through successive agricultural censuses to determine the net change in the number in each age cohort by size of farm.

Figure 8

Farm Operator Age Distribution, 1920-74



Source: (25).

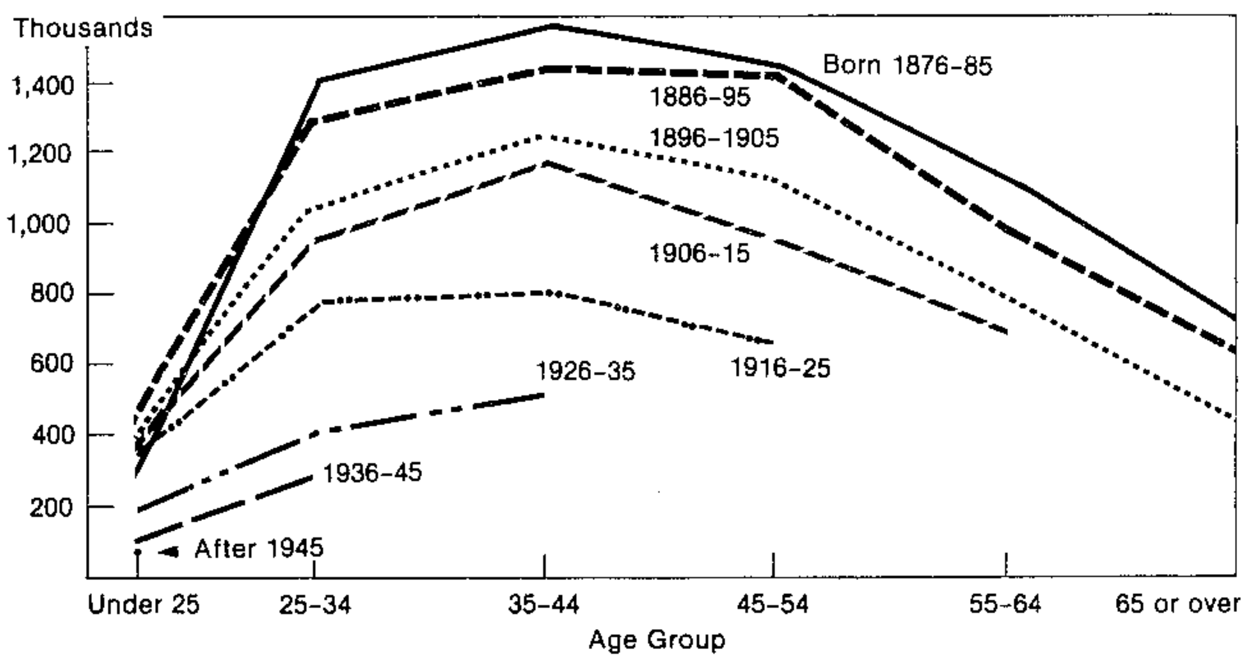
Kanel found that most of the adjustments occur as the older operators leave farms (14). Using Kanel's age cohort framework, Tolley stratified farm operators by size of farm and further examined mobility (22). He found considerable variation in entry and exit rates by age group and sales class.

Age cohort analysis centers on identifying the common pattern of entry and exit related to operator age. From census of agriculture data, the same cohort group of farm operators with common birthdates can be identified in successive censuses and the changes in net entry and exits for each age group can be estimated (figure 9). For example, for the cohort born from 1876 to 1885, some 1.4 million were farm operators when they reached the ages of 25 to 34 (in the 1910 Census). The number increased in the next decade to 1.6 million (1920) and declined slightly by 1930, by which time the cohort was 45 to 54 years old. This cohort declined to 1 million farm operators by 1940 (ages 55 to 64) and to 745,000 to 1950 (ages 65 to 75). All are assumed to have exited by 1960 as they reached 75 years of age. A few of these older operators may have continued farming, but beyond this point the Census does not provide data.

A similar pattern for other cohorts is shown in figure 9. The number of farmers in each group expands to a peak at 35 to 44 years and then declines through death or retirement. Some differences in slopes are revealed for individual cohorts. For example, the cohort born in 1916-25 was disrupted by World War II, and a new pattern seems to have emerged. Younger operators entered farming at previous rates, but a large number left farming after 35 years of age--10 years younger than previous age groups began to leave farming.

Figure 9

Farm Operator Age Cohort Movements, 1910-69



Source: (25).

Data Adjustments

Farm numbers declined 682,000 between 1964 and 1974 to 2.9 million; but the numbers in some age groups increased while those in others decreased (table 28). Also, farms with sales of $40,000 or more increased but smaller farms declined. The data in this as well as most of the following tables have been adjusted to the 1964 price level by a process similar to that described in the previous chapter. However, for the age-cohort sales class data, it was necessary to deflate each group separately (see appendix C for details).

The net entry rates for some sales classes for some age groups probably result from shifts to larger or smaller size classes. For example, table 28 shows that between 1964 and 1974, the 1920-29 cohort group declined in total numbers and in sales classes of $5,000 to $39,999 but increased in number for the two sales classes of $40,000 and above and the two smallest sales classes. The 22,100 increase in farm operators in the two larger sales classes probably represented not new entries but operators with increased sales during the period. The increased number of operators with sales of less than $5,000 in this cohort group in this period probably resulted from reductions in size of farming operations as the operators approached retirement, or increased nonfarm employment.

The replacement ratio of entering to exiting farm operators between 1964 and 1974 was about 0.23 for all farm operators (that means that about five operators left for each new entry) and less than 1 for farms with sales of less than $40,000. However, the ratio becomes 7 or higher for farms with sales of more than $40,000. Younger persons are apparently unwilling to enter farming on the smaller farms in sufficient numbers to replace older operators who leave, because of the inadequate levels of income from small farms. There were substantial entries of young operators on farms with sales of less than $2,500, but most of these are probably part-time operations. However, the 141,500 net entries of younger farmers (age 35 or less) on farms of that size were far less than the 611,800 older operators (age 55 or more) who departed.

Table 29 presents similar data for age cohorts by acreage with similar patterns of entry and exit related to size and age. The totals in tables 28 and 29 differ because the farm operator numbers by sales class for 1974 were deflated to 1964 price levels. This resulted in some of the smaller farms not meeting the minimum sales requirement when the sales were deflated.

Projections

Future farm numbers can be projected if one assumes that future adjustments and phases of successive cohorts will follow the patterns of the previous ones. The adjustments in the cohort groups are computed as the ratio of two periods and the ratios are applied to the succeeding base-period cohorts.

Figure 10 shows the cohort movements, number changes, and projected farm operator numbers by age group. For example, if we trace the 1920-29 cohort by 10-year periods starting with 1964, we find 740,000 farm operators in the 35-44 year group. By 1974, 98 percent of the group remained in farming, namely 728,300 farm operators of the age of 45-54 years old. This implies a cohort

Table 28--Change in farm operator numbers by age cohort, by sales class, 1964-74

Cohort by year of birth	Age at 1974 Census	Less than $2,500	$2,500 to 4,999	$5,000 to 9,999	$10,000 to 19,999	$20,000 to 39,999	$40,000 to 99,999	$100,000 or more	Total
	Years	Farmers							
After 1949	Less than 25	22.8	8.5	10.6	9.1	5.4	2.4	0.4	59.3
1940 to 1949	25 to 34	118.7	21.9	30.2	30.6	24.8	16.8	4.8	243.8
1930 to 1939	35 to 44	95.5	7.7	10.1	1.2	10.3	19.5	9.0	153.3
1920 to 1929	45 to 54	12.6	12.8	-13.1	-27.7	-4.8	15.4	6.7	-23.7
1910 to 1919	55 to 64	-83.3	-37.5	-50.7	-53.8	-15.8	3.4	0	-237.7
1900 to 1909	65 to 74	-101.7	-51.2	-7.8	-62.3	-24.3	-6.9	-2.1	-326.5
Before 1900	75 or older 1/	-426.8	-88.9	-63.8	-37.2	-7.0	-7.7	-2.7	-644.1
Total	NA	-362.2	-152.3	-154.7	-140.1	-21.4	43.0	16.1	-771.6
Net entry	NA	249.6	50.9	50.9	40.9	40.5	100.6	37.0	456.4
Net exits	NA	974.0	329.9	290.1	321.1	73.3	14.6	4.8	2,003.6
Replacement rate	NA	.26	.15	.18	.13	.55	6.89	7.71	.23

1/ Assumed all operators 65 years and older in 1964 would have exited by 1974 or before the age of 75.
NA = Not applicable.

Source: U.S. Dept. of Commmerce, Bureau of the Census, Census of Agriculture; adjusted for reported undercounting; excludes abnormal farms; 1974 sales classes adjusted to 1964 prices.

ratio of 0.98 for the group born between 1920 and 1929. To project the number in this cohort to 1984, cohort ratio for the 45-54 years age group in 1964 and the 55-64 years age group in 1974 (0.77) is multiplied by the number of farm operators of the 45-54 years age group in 1974 (728,300). Therefore, 563,000 farm operators are projected for the 55-64 age group in 1984. Following the same procedure, 366,000 farm operators of age 65-74 are projected for 1994. No farm operators in this cohort will remain in farming by the year 2004, since we assume that all farm operators will leave farming by age 75. 15/

The projected numbers of farm operators by age group to the year 2004 are shown in figure 10. Summing the numbers in each group for each year indicates that the total number of farm operators is likely to continue to decline. The number is projected to decline from 2.9 million in 1974 to about 2.4 million in 1984, 2 million in 1994, and 1.6 million in 2004.

15/ The cohort ratios for the under 25-year old group are calculated differently. The Census reports no data for this group as they would have been less than 15 years old in the earlier period. To calculate their entry rates we assumed that these youngest entries were replacing their fathers and we allowed up to a 40-year age difference, as suggested by Tolley (21). So the ratio became the number of farm operators who are less than 25 years old in a specific year divided by the total of the farm numbers in the 35-44 and 45-54 age group enumerated 10 years earlier.

Table 29--Change in farm operator numbers, by age cohort and farm size, 1964-74

Cohort by year of birth	Age at 1974 Census	1-99 acres	100-219 acres	220-449 acres	500-999 acres	1,000-1,999 acres	2,000 acres and over	Total
	Years	1,000 farmers						
After 1949	Less than 25	29.4	15.2	11.6	3.7	1.3	.7	61.9
1940-49	25-34	123.1	52.7	43.2	19.7	8.4	4.7	251.8
1930-39	35-44	89.9	25.8	14.3	16.2	8.8	55.9	160.9
1920-29	45-54	13.4	-17.5	-22.1	5.3	5.6	3.6	11.7
1910-19	55-64	-67.9	-70.1	-58.6	-13.1	-2.9	-1.6	-214.2
1900-09	65-74	-93.0	-89.4	-71.8	-21.4	-7.0	-3.8	-286.4
Before 1900	75 or older 1/	-363.1	-156.7	-79.6	-25.3	-10.4	-9.0	-644.1
Total	NA	-268.2	-240.0	-163.0	-14.9	3.8	.5	-681.8
Net entry	NA	242.4	93.7	69.1	39.6	18.5	11.3	474.6
Net exits	NA	456.1	246.1	151.4	46.7	17.4	12.8	930.5
Replacement rate	NA	.53	.38	.46	.85	1.06	.88	.51

NA = Not applicable.
1/ Assumed all operators 65 years and older in 1964 would have exited in 1974 before the age of 75.

Source: (25), adjusted for reported undercounting, excludes abnormal farms.

Sales Distribution

Following the same procedure, the numbers of farm operators by sales class and acreage can be projected based on the age cohort ratios presented in tables 30 and 31. The entry rates are higher for the larger size groups as indicated by the larger cohort ratios. On the other hand, the ratios are higher for the smaller classes than the mid-classes, suggesting a real possibility of a bimodal distribution of the number of farms in the future. Also, the retention rates for older operators are higher in the larger and smallest size classes.

Of the projected 1.7 million farms in 2004, large farms (sales of at least $100,000) will account for about 38 percent, an increase from 5 percent in 1974. By contrast, small farms (sales of less than $20,000) will account for 49 percent, down from 72 percent in 1974 (table 32). However, part of the increase in the percentage of large farms is due to the anticipated price inflation. When sales receipts are expressed in 1964 price levels, the proportion reduces to only 9 percent. The number of farms reduces from the projected 620,000 to 129,300 in 2004 (table 33).

Figure 10

Farm Operator Age Cohort Movements, 10 Year Periods

Current Age (Years)	1964	Cohort Ratio	1974 *		1984 •		1994 •		2004 •
		.037△		.037		.037		.037	
Less than 25	61.2	5.12	61.9	5.12	45.6	5.12	35.3	5.12	33.6
25-34	350.0	1.46	313.0	1.46	316.5	1.46	233.3	1.46	180.7
35-44	740.0	0.98	510.9	0.98	457.0	0.98	462.1	0.98	340.6
45-54	942.6	0.77	728.3	0.77	502.7	0.77	449.6	0.77	454.7
55-64	818.8	0.65	728.4	0.65	563.0	0.65	388.6	0.65	347.6
65-74	644.1	□	532.4	□	473.4	□	366.0	□	252.6
75 or older	0		0		0		0		0
Total	3,556.7		2,874.9		2,358.2		1,934.9		1,609.7

* Data rounded after calculations.

△ The ratio is defined as all new entrants under 25 years divided by the number of operators who, 10 years earlier, were 35-54 years old (see text for more detail).

□ Assume all exits by age 75.

• 1984, 1994, and 2004 are projections.

Numbers in boxes are in thousands.

Table 30--Ratio of 1974 farmers to 1964 farmers by age cohort and sales class 1/

Cohort birth year	Age in 1974 Census	Less than $2,500	$2,500-4,999	$5,000-9,999	$10,000-19,999	$20,000-39,999	$40,000-99,999	$100,000 or more	Total
	Years	Ratio 2/							
After 1949	Under 25 3/	0.03	0.04	0.04	0.03	0.03	0.04	0.02	0.04
1940-49	25-34	5.54	3.38	3.85	4.22	6.83	14.48	23.17	5.05
1930-39	35-44	1.69	1.19	1.19	1.02	1.27	2.29	3.56	1.14
1920-29	45-54	1.04	.85	.88	.78	.94	1.45	1.70	.97
1910-19	55-64	.79	.70	.67	.64	.80	1.10	1.00	.75
1900-09	65 or more	.73	.59	.44	.40	.49	.65	.66	.60

1/ 1974 sales class data adjusted to 1964 prices.
2/ The number of 1974 farmers in each sales class and each age cohort divided by the number of 1964 farmers in the same sales class and age cohort.
3/ The ratio for this age cohort is defined as all new entrants under 25 divided by the number of operators who, 10 years earlier, were 35-54 years old (see text for more detail).

Table 31--Ratio of 1974 farmers to 1964 farmers, by age cohort and size of farm 1/

Cohort birth year	Age in 1974 Census	1-99 acres	100-219 acres	220-499 acres	500-999 acres	1,000-1,999 acres	2,000 or more acres	Total
	Years	Ratio 2/						
After 1949	Under 25 3/	0.04	0.04	0.03	0.03	0.03	0.02	0.04
1940-49	25-34	4.99	4.52	4.89	7.83	10.74	10.20	5.12
1930-39	35-44	1.59	1.31	1.19	1.64	1.91	2.05	1.46
1920-29	45-54	1.04	.90	.86	1.10	1.25	1.25	.98
1910-19	55-64	.83	.71	.70	.81	.89	.91	.77
1900-09	65 or more	.75	.59	.51	.56	.64	.72	.65

1/ Ratios for acre size differ slightly from those by sales classes because sales class data were deflated to 1964 prices.
2/ The number of 1974 farmers in each sales class and each age cohort divided by the number of 1964 farmers in the same sales class and age cohort.
3/ The ratio for this age cohort is defined as all new entrants under 25 divided by the number of operators who, 10 years earlier, were 35-54 years old (see text for more detail).

Table 32--U.S. farm operators by sales class, selected years and projections

Year	Less than $2,500	$2,500-$4,999	$5,000-$9,999	$10,000-$19,999	$20,000-$39,999	$40,000-$99,999	$100,000 or more	Total
				1,000 farmers				
1964	1,657.3	473.9	528.6	484.1	266.9	113.5	32.4	3,556.7
1974	1,400.6	322.9	319.5	326.9	327.6	327.5	149.9	2,874.9
1984	750.0	250.0	250.0	200.0	200.0	335.0	365.0	2,350.0
1994	820.0	158.0	100.0	80.0	120.0	220.0	580.0	2,078.0
2004	490.0	80.0	100.0	120.0	80.0	160.0	620.0	1,650.0
				Percent				
1964	46.6	13.3	14.9	13.6	7.5	3.2	.9	100.0
1974	38.3	11.2	11.1	11.4	11.4	11.4	5.2	100.0
1984	31.9	10.6	10.6	8.5	8.5	14.3	15.5	100.0
1994	39.6	7.3	4.8	3.9	5.8	10.6	28.0	100.0
2004	29.7	4.8	6.1	7.3	4.8	9.7	37.6	100.0

Table 33--U.S. farm operators by sales class, in 1964 prices, selected years and projections

Year	Less than $2,500	$2,500-$4,999	$5,000-$9,999	$10,000-$19,999	$20,000-$39,999	$40,000-$99,999	$100,000 or more	Total
				1,000 farmers				
1964	1,657.3	473.9	528.6	484.1	266.9	113.5	32.4	3,556.7
1974	1,295.1	321.6	373.9	344.0	245.5	156.5	48.5	2,785.1
1984	1,068.1	207.9	252.4	225.0	208.2	203.1	68.8	2,233.5
1994	859.1	129.9	165.7	135.9	160.2	249.5	96.6	1,796.9
2004	663.7	80.4	107.5	78.9	114.6	291.0	129.3	1,465.4
				Percent				
1964	46.6	13.3	14.9	13.6	7.5	3.2	.9	100.0
1974	46.5	11.6	13.4	12.4	8.8	5.6	1.7	100.0
1984	47.8	9.3	11.3	10.1	9.3	9.1	3.1	100.0
1994	47.8	7.2	9.2	7.6	8.9	13.9	5.4	100.0
2004	45.3	5.5	7.3	5.4	7.8	19.9	8.8	100.0

Acreage Distribution

Table 34 presents the distribution of farm operator numbers by acre size group for 1964, 1974, and projections for 1984, 1994, and 2004. The projections show declining numbers in all acre sizes, except the 1,000 to 1,999 acre size, through 2004. The numbers of farm operators who farm more than 1,000 acres account for 10 percent of the total number, an increase from 5.5 percent in 1974. By contrast, the proportion of small farm operators with less than 220 acres is projected to remain the same in 2004, about 70 percent. Actually, the number of farm operators with less than 100 acres is projected to account for an increasing percentage of the total.

Table 34--U.S. farm operators, by size of farm, selected years and projections

Year	1-99 acres	100-219 acres	220-500 acres	500-999 acres	1,000-1,999- acres	2,000 or more acres	Total
				1,000 farms			
1964	1,625.1	890.0	665.1	225.1	89.8	61.6	3,556.7
1974	1,356.9	649.9	502.1	210.3	93.6	62.1	2,874.9
1984	1,171.2	472.7	366.4	192.0	95.5	60.4	2,358.2
1994	1,005.1	345.0	258.4	172.8	96.5	57.1	1,934.9
2004	862.4	256.8	182.5	156.1	98.0	53.9	1,609.7
				Percent			
1964	45.7	25.0	18.7	6.3	2.5	1.8	100.0
1974	47.2	22.6	17.4	7.3	3.3	2.2	100.0
1984	49.7	20.0	15.5	8.1	4.1	2.6	100.0
1994	51.9	17.8	13.4	8.9	5.0	3.0	100.0
2004	53.5	16.0	11.3	9.7	6.1	3.4	100.0

COMPARISON OF ALTERNATIVE PROJECTIONS

Up to this point, we have presented projections of farm numbers and size distributions to 2000 for each of the four most frequently used projection methods. This chapter summarizes those projections and compares them for accuracy and reasonableness. A set of "most likely" projections were presented earlier.

All the projections point to a continuous decline in farm numbers, to about 1.75 million farms by 2000, although the estimate varies by the method used and whether the projection is by acreage or sales size. The trend extrapolation and Markov process analysis closely aprallel one another for acreage distribution, while the negative exponential function performs erratically. For sales distributions, the Markov process and age cohort analysis give very consistent projections; negative exponential functions again perform poorly.

Acreage distributions projected to 2000 by trend extrapolation, Markov process, and age cohort analysis are very consistent. Negative exponential functions probably underestimate the percentage of small farms, and overestimate that for medium-size and large farms (table 35). The projected total number of farms, based on the acreage distribution, varies from 1.7 million to 1.8 million in 2000. The small deviations among the methods give confidence in projecting the acreage distributions of farm numbers (fig. 11). Unfortunately, farmland acreage is not the best size measure. Frequently, sales receipts are preferred to farmland acreage as a size measure. Furthermore, the new definition of a farm adopted by the U.S. Department of Agriculture in 1978 makes it almost necessary to base projections on sales.

Total farm number projections based on the sales distribution vary more widely, however, ranging from 1.9 million to 2.1 million in 2000 (fig. 12). The large number of farms obtained from trend extrapolation is partly due to the erratic trend equation for farms with $20,000 to $39,999 in sales. Instead of projecting a downturn (a trend established from 1969 to 1974), an upward increasing trend is projected. Markov process and age cohort analysis, on the other hand, give very consistent projections.

Table 35--Comparison of alternative projections by size class in 2000

Alternative projections	Size of farm (acres): Less than 220	Size of farm (acres): 220 to 999	Size of farm (acres): 1,000 and over	Sales class: Less than $20,000	Sales class: $20,000-$99,999	Sales class: $100,000 and over
	Percent of total farms					
1974 actual	69.8	24.8	5.4	72.0	22.8	5.2
Trend extrapolation	61.4	28.7	9.9	39.1	46.8	14.1
Negative exponential functions	34.6	51.0	14.4	5.8	20.1	74.1
Markov process	67.7	22.4	9.9	49.9	18.8	31.3
Age cohort analysis	69.5	21.7	8.8	51.8	15.5	32.8

Figure 11

Projected Numbers of Farms Based on Acreage Distribution

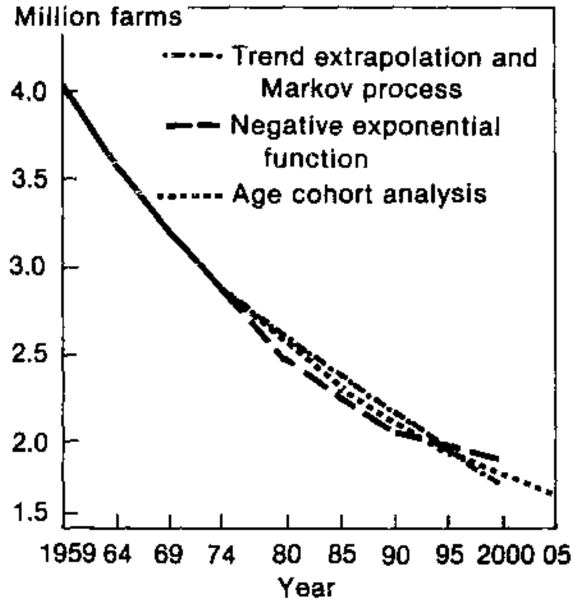
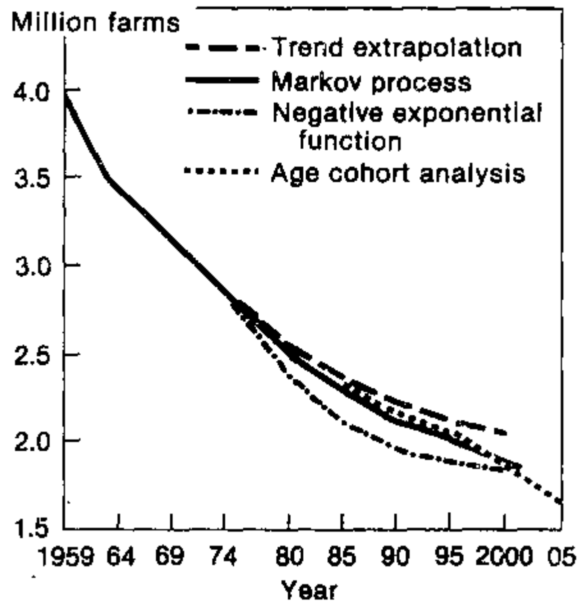


Figure 12

Projected Numbers of Farms Based on Sales Distribution



The decline in the percentage of small farms (less than 220 acres) and the increase in large farms (1,000 acres and more) are less apparent than the changes in the total number of farms would lead us to believe. While the U.S. farm sector experienced a 19-percent decline in the number of all farms between 1964 and 1974, the decline in the percentage of small farms was negligible--from 71 percent in 1964 to 70 percent in 1974. Similarly, the percentage of the large farms increased by only 1 point, from 4 percent in 1964 to 5 percent in 1974. This size configuration of American farm structure is projected to continue into 2000.

The sales distribution of farm numbers is projected to have a more apparent shift from those with low sales to those with high, partly due to the anticipated high price inflation. By 2000, small farms (sales of less than $20,000) are likely to account for 50 percent of the total, a decline from 72 percent in 1974. By contrast, the percentage of large farms (sales of $100,000 and more) is projected to increase to 32 percent, a rise from 5 percent in 1974.

The procedure used to measure the percentage error between the actual and projected number of farms is the inequality coefficient (U) developed by Theil (21):

$$U = \sqrt{\frac{\sum_{i=1}^{n} (\hat{Y}_i - Y_i)^2}{\sum_{i=1}^{n} Y_i^2}}$$

where U = the Theil inequality coefficient,
$\hat{Y}_i$ = projected number of farms in size class i, and
Y_i = actual number of farms in size class i.

The accuracy of projections is determined primarily by comparing actual 1974 numbers with projections. To further indicate the degree of projection accuracy in each size class, the simple percentage differences are also shown.

The accuracy of the projections differs among the four projection methods. In general, projections of farm numbers and size distributions by acreage tend to be more accurate than those by sales. This is understandable since projections by sales are complicated by the inflation factor. Even though specific attempts were made to account for the effects of inflation in changes in farm numbers of the Markov chain and age cohort analyses, some errors of measurement probably remain.

Simple trend extrapolation typically gives fairly accurate projections by acreage, but commits a larger error of projections by sales (tables 36 and 37). A 13.2-percent error rate was found for the projections by sales in 1974, but the error rate was greater for farms with sales of $40,000 and over. 16/ This partly reflects the fact that the simple trend extrapolation tended to underestimate the shifts in farm numbers from low to high sales as a result of the 80-percent increase in prices received by farmers during the 1969-74 period. The projected numbers of small farms do not differ significantly from actual 1974 numbers.

The simple trend extrapolation method in years other than 1974 yielded a similar accuracy and pattern. Theil-U inequality coefficients of 0.0151 and 0.0084 were computed for 1964 and 1969 projections based on acreage. Those low numbers reflect the insignificant changes in prices received by farmers in the sixties.

The negative exponential function is a procedure to project the size distribution, especially when acreage is used as the size measure. As we indicated before, this method was not very satisfactory for projections based on

16/ The U coefficient of 0.13 for the trend extrapolation by sales class means that there is an average difference of 13 percent between actual and projected farm numbers in 1974. The smaller the U coefficients, the better is the projection accuracy.

Table 36--Projected number of farms by acreage in 1974, simple trend extrapolation

Size of farm	Actual 1974	Projected 1974	Percent difference 1/
	Number		Percent
1-99 acres	1,356,905	1,336,748	-1.49
100-219 acres	649,923	652,620	+0.41
220-499 acres	502,148	512,344	+2.03
500-999 acres	210,702	214,218	+1.67
1,000-1,999 acres	93,264	83,599	+0.36
2,000 acres and over	61,994	60,947	-1.69
All farms	2,874,936	2,870.476	-0.15

1/ Theil-U = 0.0144 or 1.44 percent.

Table 37--Projected number of farms by sales in 1974, simple trend extrapolation

Sales class	Actual 1974	Projected 1974	Percent difference 1/
	Number		Percent
Less than $2,500	1,100,597	1,136,826	3.29
$2,500-$4,999	322,949	328,651	1.77
$5,000-$9,999	319,474	319,576	0.03
$10,000-$19,999	326,905	338,660	3.60
$20,000-$39,999	327,567	340,698	4.01
$40,000-$99,999	327,516	258,785	-20.99
$100,000-$199,999	99,385	68,101	-31.48
$200,000-$499,999	39,335	26,390	-32.91
$500,000 and over	11,206	8,232	-26.54
All farms	2,874.934	2,825.919	-1.70

1/ Theil-U = 0.1316 or 13.16 percent.

sales, yielding a 94-percent error for 1974 sales projections (table 38). 17/ This procedure proved equally unsatisfactory to project farm numbers based on acreage, yielding errors of 68 percent (table 39). Those results suggest that considerable discrepancies still exist between the actual and estimated distribution functions obtained by the negative exponential function. As shown in table 38, there are significant underestimates in the smaller size classes and overestimates in the medium and larger classes. Also, this function overestimates the numbers of farms with sales between $10,000 and $500,000 by factors ranging from 1.5 to 4.5, and underestimates the number of farms with sales less than $10,000.

Markov chain analysis, modified somewhat in this study to adjust for the effects of price inflation on changes in farm numbers, appears to be promising. The errors of projection, by both acreage and sales, in 1974 were about 4 and 0.1 percent (tables 40 and 41). In contrast to previous applications, there are no gross estimation errors evidenced in these projections. It is essential to capture the effects of price inflation in an era of price instability to avoid gross distrotions and inaccuracies in projections of farm numbers by sales.

In addition, those results suggest that the underlying assumption of the Markov process on the growth of farms is questionable. Instead of a farm's growing from the smallest to the largest size, the census data suggest that the largest farms tend to come from smaller farms of a minimum viable size, and not from the smallest size classes.

Age cohort projections tend to be similar to those from the Markov process. Compared with 1969 actual farm numbers by both acreage and sales, age cohort analysis yielded a 10.9-percent and a 16-percent error according to the Theil-U coefficient (tables 42 and 43). 18/ Age cohort analysis appears to underestimate farms with $2,500 to $4,999 sales and to overestimate those with $20,000 to $39,999 sales.

17/ The percentage error is derived from comparing actual proportions of 1974 farm numbers by size class with projected percentages. In this way, the comparison is not complicated by projections on land in farms and acreage farm size.

18/ In projecting the 1969 number of farms by acreage, the cohort ratios constructed from the 1950-59 period were multiplied by the age-size distributions in 1959. For sales, a 1959-69 cohort-ratio matrix was multiplied by the 1964 age-size matrix to project the 1974 farm numbers by sales class. This procedure overlapped 5 years of calculation of the age cohort ratios and the projection period. This was necessary because different sales class intervals were published by the Bureau of the Census before 1959.

Table 38--Projected proportions of 1974 farm numbers by sales, class, negative exponential function

Sales class	Actual	Projection	Percentage difference 1/
		Percent	
Less than $2,500	38.3	4.5	-88.3
$2,500-$4,999	11.2	4.3	-61.6
$5,000-$9,999	11.1	6.2	-44.1
$10,000-$19,999	11.4	14.3	25.4
$20,000-$39,999	11.4	20.7	81.6
$40,000-$99,999	11.4	32.3	183.3
$100,000-$199,999	3.4	14.5	326.4
$200,000-$499,999	1.4	2.2	57.1
$500,000 and over	.4	1.0	150.0
All farms	100.0	100.0	NA

NA means not applicable.
1/ Theil-U = 0.941 or 94.1 percent.

Table 39--Projected proportions of 1974 farm numbers by size of farm, negative exponential functions

Size of farm	Actual	Projection	Percentage difference 1/
		Percent	
1-69 acres	37.2	14.7	-60.5
70-99 acres	10.0	5.7	-43.0
100-139 acres	9.0	7.0	-22.2
140-179 acres	8.3	6.4	-22.9
180-219 acres	5.3	5.7	7.5
220-259 acres	4.3	5.3	23.3
260-499 acres	13.2	23.4	77.3
500-999 acres	7.3	21.7	197.3
1,000-1,999 acres	3.2	9.1	184.4
2,000 acres and over	2.2	1.0	-54.5
All farms	100.0	100.0	NA

NA means not applicable.
1/ Theil-U = 0.681 or 68.1 percent.

Table 40--Projected number of farms, by size of farm, 1974, Markov process

Size of farm	Actual	Projected	Percent difference
	Number		
1-69 acres	1,069,433	1,027,082	-3.96
70-99 acres	287,472	287,137	-0.12
100-139 acres	258,690	265,079	2.47
140-179 acres	239,786	245,530	2.40
180-219 acres	151,447	155,180	2.46
220-259 acres	122,851	127,105	3.38
260-499 acres	379,297	392,479	3.47
500-999 acres	210,702	219,227	4.04
1,000-1,999 acres	93,264	93,898	0.68
2,000 acres and over	61,994	61,889	-0.17
All farms	2,874,936	2,874,506	-0.01

1/ Theil-U = 0.0367 or 3.67 percent.

Table 41--Projected number of farms by sales class, 1974, Markov process

Sales class	Actual	Projected	Percent difference
	1,000 Farms		Percent
Less than $2,500	1,100.6	1,109.7	.8
$2,500-4,999	322.9	322.9	0
$5,000-9,999	319.5	320.4	.3
$10,000-19,999	326.9	328.2	.4
$20,000-39,999	327.6	322.3	-1.6
$40,000-99,999	327.5	322.1	-1.6
$100,000-199,999	99.4	97.3	-2.1
$200,000-499,999	39.3	38.5	-2.0
$500,000 and over	11.2	11.0	-1.8
All farms	2,874.9	2,872.4	-.1

1/ Theil-U = 0.0007 or 0.07 percent.

Table 42--Projected 1969 farm numbers, by size of farm, age-cohort analysis 1/

Size of farm	Actual	Projected	Percent difference
	----------------Number----------------		----Percent----
Less than 10 acres	162,111	120,221	25.8
10-49 acres	473,465	407,655	13.9
50-69 acres	177,028	140,847	20.4
70-99 acres	282,914	231,065	18.3
100-139 acres	278,752	240,448	13.7
140-179 acres	263,012	244,752	6.9
180-219 acres	165,209	164,682	3.2
220-259 acres	141,733	149,074	5.2
260-499 acres	419,421	419,189	.1
500-999 acres	215,659	194,967	9.6
1,000 acres or more	150,946	137,432	9.0
Total	2,730,250	2,450,332	10.3

1/ Not adjusted for census underenumeration; Theil-U is 0.1087 or 10.9 percent.

Table 43--Projected 1974 farm numbers by sales class, age-cohort analysis 1/

Sales Class	Actual	Projected	Percent difference
	----------------Number----------------		----Percent----
Less than $2,500	768,838	800,000	4.1
$2,500-$4,999	289,983	155,000	-45.6
$5,000-$9,999	296,373	260,000	-12.3
$10,000-$19,999	310,011	355,000	14.5
$20,000-$39,999	321,771	390,000	21.2
$40,000-$99,999	324,310	345,000	6.4
$100,000 or more	152,599	165,000	8.1
All farms	2,463,885	2,450,000	.6

1/ Not adjusted for census underenumeration; the Theil-U is 0.16 or 16 percent. The accuracy for the farm operator age distribution was very good, only 2.1 percent error of projection was computed. Projections presented in this table have been adjusted to take into account the effects of price inflation.

CONCLUSIONS AND IMPLICATIONS

The techniques employed in this study used several kinds of data and assumptions in projecting farm numbers and size distributions. The specific projections are, therefore, contingent upon the techniques, assumptions, and data employed. The different techniques are not necessarily equally valid for examining the same questions. The results, however, provide different perspectives and suggest some common tendencies and regularities.

Although the four frequently used techniques project future number and size of farms with some regularity, their accuracy varies. In addition, the projected size distributions may differ considerably from one procedure to another, even though the projected totals are similar. For example, farm numbers by acreage projected by trend extrapolation, Markov process, and age cohort analysis are reasonably comparable. However, trend extrapolation and age cohort analysis both project a slight decline in the number of farms of 2,000 acres and over, but Markov process projects a continuous, slow increase in the number of such farms (table 44).

Trend extrapolation gives fairly accurate projections by acreage, but commits a large projection error in sales distribution. Unlike the continuous trends for the acreage distribution, some of the trends for the sales distribution occasionally reverse. Trend projections, under this circumstance, could lead to an incorrect direction. For example, the number of farms with sales of $20,000 to $39,999 increased from 1959 to 1969, but then declined after 1969. Once a new trend is established, it is likely to continue to project an increasing trend for the number of such farms.

Table 44--Alternative projections of farm numbers, by size of farm, 2000

Size of farm	1974 Actual	Trend extrapolation	Negative exponential functions	Markov process	Age cohort
			1,000 farms		
1-99 acres	1,356	751	320	864	934
100-139 acres	259		113	121	
140-179 acres	240	300	104	102	301
180-219 acres	151		96	66	
220-259 acres	123	286	89	48	220
260-499 acres	379		712	182	
500-999 acres	211	205	430	152	164
1,000-1,999 acres	93	108	224	91	97
2,000 acres and over	62	61	37	77	56
All farms	2,875	1,711	1,826	1,705	1,772

Projected total numbers of farms and those for the medium-size groups (sales of $20,000 to $99,999) obtained from the trend extrapolation appear to be overestimated. This reflects another serious problem with this technique. Even though there was a consistent, increasing trend which occurred in the past, the number of farms may begin to decline at some point in the future. For example, despite the continuous, increasing trend for the number of farms with sales of $40,000 to $99,999, a decline in the number is projected by other techniques (table 45). Thus, a simple trend extrapolation fails to foresee that the trend can be reversed. Finally, the trend extrapolation, by failing to capture the effects of inflation on changes in farm numbers, makes a larger projection error. If inflation is higher in the future, then the number of farms in the upper sales classes is likely to be underestimated as evidenced in table 45.

The numbers of farms projected by negative exponential functions differ significantly from those obtained by other procedures and apparently have larger percentage errors. The number of projected small farms (sales of less than $20,000) is too low and the number of projected large farms (sales of $100,000 and over) is too high. The large projection errors when this technique is applied to sales distributions are expected, but projections by acreage distribution are not much better. The projected numbers of farms with 1 to 99 acres and 2,000 acres and over are much smaller than those projected by other procedures. On the other hand, the projected numbers of farms with 260 to 1,999 acres appear to be much too large, and present a discontinuity to the recent trends. In short, evidence suggests that while the distributional functions are stable over time, an empirical approximation of the true theoretical function shows a considerable discrepancy.

Table 45--Alternative projections of farm numbers by sales class, 2000

Sales class	1974 actual	Trend extrapolation	Negative exponential functions	Markov process	Age cohort
	1,000 farms				
Less than $2,500	1,101	456	13	640	655
$2,500-4,999	323	111	13	72	119
$5,000-9,999	319	90	29	108	100
$10,000-19,999	327	164	53	108	100
$20,000-39,999	328	443	102	88	100
$40,000-99,999	328	539	271	262	190
$100,000-199,999	99	188	354	168	600
$200,000-499,999	39	81	606	190	
$500,000 and over	11	27	417	226	
All farms	2,875	2,109	1,857	1,862	1,864

The Markov process and age cohort techniques give very similar projections. However, we found that the traditional farm growth assumption, underlying the Markov process is questionable. Census data suggest that firms tend to enter farming at an economically viable size and then expand. The age cohort techniques incorrectly project a slight decline in the number of farms with 2,000 acres and over. By contrast, the Markov process projects a moderate increase--a trend more consistent with the past. In sum, Markov process and age cohort techniques appear to be more promising for projecting sales distributions.

The most likely projections for the number of farms are synthesized from projections based on the acreage distribution from trend extrapolation and Markov process. The small deviations between the two methods and the fact that the projections are free of any estimation errors in accounting for the effects of price inflation, gives us confidence in projecting the total number of farms. Farm numbers are, therefore, projected to decline from 2.87 million in 1974 to 2.32 million in 1985, 2.09 million in 1990, 1.89 million in 1995, and 1.75 million in 2000.

Projections on farm numbers by acreage are computed by multiplying the most likely total number of farms by a synthesized distribution of farm numbers obtained from trend expolation and Markov process projections, since the two methods yield a higher degree of accuracy in reproducing historical data. Similarly, projections on farm numbers by sales class are computed by multiplying the most likely total number of farms by a synthesized distribution of farm numbers obtained from Markov process and age cohort analysis. The most likely projections on number of farms by acreage and sales class are given in tables 5 and 6.

Most of the projections in this study are trend related, with the exception of assumptions to account for the effects of inflation on changes in farm numbers by sales. However, studies that base projections on causal economic relationships are needed. One such approach is to link the transition probabilities, as employed in the Markov process, and the cohort ratios, as used in age cohort analysis, to factors that cause structural changes. This, however, requires more detailed structural data on a longitudinal basis--that is, a data base linking the "true" structural changes from one census year to the others, and the associated factors that have caused the changes.

Further specificity is also needed for production regions and farm commodity subsectors--each of which tends to have its own unique characteristics. To make projections of the number of farms and size distribution more useful, it would also be desirable to disaggregate the study by region and by commodity subsector. Implications for other structural characteristics drawn from such projections would be more useful than those based on national averages.

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Appendix table 1--Selected structural characteristics of U.S. farms, by sales class

Item	Unit	$100,000 and over (class IA)	$40,000 to $99,999 (class IB)	$20,000 to $39,999 (class II)	$10,000 to $19,999 (class III)	$5,000 to $9,999 (class IV)	$2,500 to $4,999 (class V)	Less than $2,500 (class VI)	All Farms
Number of farms:									
1969	1,000	52.0	169.7	331.0	395.5	390.4	395.1	994.5	2,728.1
	Percent	1.9	6.2	12.1	14.5	14.3	14.5	36.5	100
1974	1,000	152.6	324.3	321.8	310.0	296.0	290.0	768.8	2,463.9
	Percent	6.2	13.2	13.1	12.6	12.0	11.8	31.2	100
Cash receipts:									
1969	Bil. dol.	15.3	10.1	9.3	5.7	2.8	1.3	.98	45.48
	Percent	33.6	22.2	20.4	12.5	6.2	2.9	2.2	100
1974	Bil. dol.	43.7	20.1	9.2	4.5	2.1	.98	.74	388.32
	Percent	53.7	24.7	11.3	5.5	2.6	1.2	.9	100
Cash receipts per farm:									
1969	Dols.	293,915	59,364	27,999	14,396	7,208	2,626	953	16,689
1974	Dols.	286,268	61,890	28,737	14,387	7,215	3,640	1,143	25,234
Form of organization:									
Sole proprietorships:									
1969	Farms	30,683	131,418	277,233	341,063	344,063	356,105	896,005	2,376,570
	Percent	59.0	77.4	83.8	86.1	88.1	90.1	90.1	87.1
1974	Farms	108,463	280,824	290,596	284,521	277,272	275,897	731,165 1/	2,248,738
	Percent	71.1	86.6	90.3	91.8	93.6	95.1	95.1	91.3
Partnerships:									
1969	Farms	13,049	33,104	49,236	49,990	41,878	34,278	86,518	308,053
	Percent	25.1	19.5	14.9	12.6	10.7	8.7	8.7	11.3
1974	Farms	27,811	37,107	27,671	22,801	17,180	12,399	33,060 1/	178,029
	Percent	18.2	11.4	8.6	7.4	5.8	4.3	4.3	7.2

See footnotes at end of table.

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Appendix table 1--Selected structural characteristics of U.S. farms, by sales class--Continued

Item	Unit	$100,000 and over (class IA)	$40,000 to $99,999 (class IB)	$20,000 to $39,999 (class II)	$10,000 to $19,999 (class III)	$5,000 to $9,999 (class IV)	$2,500 to $4,999 (class V)	Less than $2,500 (class VI)	All farms
Corporations:									
1969	Farms	8,049	4,306	2,847	2,262	1,984	2,062	4,972	2,648
	Percent	15.5	2.5	0.8	0.6	0.5	0.5	0.5	1.0
1974	Farms	15,787	5,630	2,768	1,988	1,335	1,148	3,075 1/	31,731
	Percent	10.3	1.7	.9	.6	.4	.4	.4	1.3
Other:									
1969	Farms	214	867	1,673	2,157	2,500	2,659	6,961	17,031
	Percent	.4	.5	.5	.6	.7	.7	.7	.8
1974	Farms	538	749	736	701	586	539	1,538 1/	5,387
	Percent	.4	.2	.2	.2	.2	.2	.2	.2
Land farmed by:									
Sole proprietor-ships:									
1969	Mil. acre	69.27	127.12	166.63	144.24	92.43	66.01	125.85 1/	791.55
	Percent	40.3	68.6	80.4	84.3	86.5	87.0	87.0	74.5
1974	Mil. acre	147.52	193.08	138.65	90.73	59.80	48.31	109.06 1/	787.15
	Percent	53.3	78.3	86.2	88.6	91.0	90.6	90.6	76.7
Partnerships:									
1969	Mil. acre	44.04	41.12	35.08	23.33	12.23	7.59	14.47 1/	177.86
	Percent	25.6	62.2	16.9	13.6	11.4	10.0	10.0	16.7
1974	Mil. acre	56.45	34.18	16.52	9.17	4.77	3.38	7.70 1/	132.17
	Percent	20.4	13.9	10.3	9.0	7.3	6.4	6.4	12.9
Corporations:									
1969	Mil. acre	55.94	15.49	4.15	2.57	1.15	1.55	2.89 1/	83.74
	Percent	32.6	8.4	2.0	1.5	1.1	2.0	2.0	7.9
1974	Mil. acre	69.73	18.10	4.83	2.10	0.88	1.14	2.53 1/	99.3
	Percent	25.2	7.3	3.0	2.0	1.3	2.1	2.1	9.7

See footnotes at end of table.

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Appendix table 1--Selected structural characteristics of U.S. farms, by sales class--Continued

Item	Unit	$100,000 and over (class IA)	$40,000 to $99,999 (class IB)	$20,000 to $39,999 (class II)	$10,000 to $19,999 (class III)	$5,000 to $9,999 (class IV)	$2,500 to $4,999 (class V)	Less than $2,500 (class VI)	All farms
Other:									
1969	Mil. acre	2.58	1.56	1.44	1.07	1.03	0.73	1.45 1/	9.86
	Percent	1.5	0.8	0.6	1.0	1.0	1.0	1.0	0.9
1974	Mil. acre	3.11	1.28	0.71	0.41	0.28	0.50	1.08 1/	7.37
	Percent	1.1	.5	.4	.4	.4	.9	.9	.4
Average size of farm:									
1969	Acres	3304.7	1091.9	626.2	432.9	273.6	192.0	90.3	389.0
1974	do.	1,814.0	761.0	499.0	330.0	222.0	184.0	84.5	416.0
Farm operator age distribution: (1969)									
Less than 35 yrs	Percent	11.3	13.8	14.3	12.4	11.4	10.9	11.4	12.0
35 to 54 years	do.	60.3	59.8	56.3	48.5	42.4	40.9	41.0	45.7
55 yrs. and over	do.	28.4	26.4	29.4	39.1	46.2	48.2	47.6	42.4
Average age	Years	48.1	47.4	47.7	50.0	51.9	52.8	52.0	51.2
Farm operator age distribution (1974)									
Less than 35 yrs	Percent	12.0	14.2	14.0	13.2	12.3	11.7	12.3	12.6
35 to 54 years	do.	56.4	51.4	44.7	40.5	36.9	37.6	41.1	43.2
55 yrs. and over	do.	31.6	34.4	41.3	46.4	50.8	50.7	46.7	43.6
Average age	Years	48.8	48.9	50.4	51.9	53.5	53.6	52.7	51.7
Net farm income per farm:									
1969	Dols.	31,959	13,168	7,490	3,767	1,603	-551	-268	2,940
1974	do.	63,287	20,453	9,499	4,135	1,401	-1,039	-412	8,890

See footnotes at end of table.

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Appendix table 1--Selected structural characteristics of U.S. farms, by sales class--Continued

Item	Unit	$100,000 and over (class IA)	$40,000 to $99,999 (class IB)	$20,000 to $39,999 (class II)	$10,000 to $19,999 (class III)	$5,000 to $9,999 (class IV)	$2,500 to $4,999 (class V)	Less than $2,500 (class VI)	All farms
Off-farm income per farm: 1/									
1969	Dols.	7,471	3,865	3,212	3,858	5,094	5,757	6,964	5,537
1974	do.	8,060	4,997	5,512	7,444	9,640	11,566	12,411	9,487
Payments government farm programs per farm:									
1969	do.	15,018	5,679	3,407	2,330	1,511	1,028	565	2,242
1974	do.	3,890	1,677	1,336	1,083	811	715	400	1,305
Capital gains on farm assets per farm:									
1969	do.	36,765	12,655	7,442	4,848	3,167	2,314	1,333	4,106
1974	do.	71,273	30,560	18,541	12,289	8,074	6,242	4,209	13,770
Total net income per farm 2/:									
1969	do.	54,448	22,712	14,109	9,955	8,208	6,234	7,261	10,719
1974	do.	75,237	27,127	16,347	12,662	11,852	11,242	12,399	19,682
Assets, debts per farm, 1969:									
Assets	do.	852,456	314,949	181,773	119,426	80,395	60,969	40,991	106,780
Debts	do.	210,088	65,101	33,439	20,331	10,821	5,267	3,458	17,981
Debt/asset ratio	Percent	24.6	21.4	18.4	17.0	13.5	8.6	8.4	16.8
Assets, debts per farm, 1974									
Assets	Dols.	954,326	380,511	224,328	150,760	108,299	91,770	73,746	186,472
Debts	do.	287,830	58,549	29,712	16,027	8,892	5,039	3,375	29,575
Debt/asset ratio	Percent	30.2	15.4	13.2	10.6	8.2	5.5	4.6	15.9

See footnotes at end of table.

-----Continued-----

Appendix table 1--Selected structural characteristics of U.S. farms, by sales class--Continued

Item	Unit	$100,000 and over (class IA)	$40,000 to $99,999 (class IB)	$20,000 to $39,999 (class II)	$10,000 to $19,999 (class III)	$5,000 to $9,999 (class IV)	$2,500 to $4,999 (class V)	Less than $2,500 (class VI)	All farms
Tenure of farm operators--1969									
Full owners	Percent	35.3	32.6	36.4	45.9	59.3	69.4	82.8	62.5
Part owners	do.	51.4	51.3	45.4	36.8	25.7	17.9	9.0	24.6
Tenants	do.	13.3	16.1	18.2	17.3	15.0	12.7	8.2	12.9
Tenure of farm operators--1974									
Full owners	do.	29.3	33.3	45.4	58.8	69.1	75.3	84.0	61.5
Part owners	do.	57.2	50.8	38.7	27.3	19.8	15.7	10.1	27.2
Tenants	do.	13.5	15.9	15.9	13.9	11.1	9.0	5.9	11.3

1/ Number of farms estimated by the authors by assuming that the number of farms and land in farms in this sales class follow the same distribution pattern among the various types of organization in sales class V where sales range from $2,500 to $4,999. Direct census data on these items are not available.

2/ Total net income per farm include net farm income, off-farm income, and farm program payments. Capital gains on farm assets are excluded.

APPENDIX A

Data Adjustments for Underenumeration of the 1974 Census of Agriculture Data

This adjustment process uses the evaluation of coverage results reported by the U.S. Census Bureau, specifically the percentage of farms enumerated by farm size (24). An estimate of missed farms is then computed for each size class. But, the sum of the estimated missed farms frequently exceeds the total of missed farms, suggesting that another round of adjustments is needed. The second-round estimates of missed farms are computed by assuming that the discrepancy between the two estimates can be eliminated in proportion to the first-round estimates of missed farms in each size class. The adjusted farm numbers are then obtained by adding the revised estimates of missed farms to the numbers of farms reported by the census. This implies, however, that the number of abnormal farms, after adjusting for underenumeration (column 9 in appendix table 2), should be deducted from column 8. Therefore, a complete comparability is maintained for column 8 in appendix table 2 and column 10 in appendix table 3, with each showing the number of farms by size class adjusted for underenumeration and excluding normal farms.

Appendix table 2--Adjustment process for underenumeration of the 1974 Census of Agriculture data by sales class

Sales class	Number of farms 1/	Farms included in census	First-round adjustment of number of farms	First-round estimate of missed farms 3/	Total missed farms	Second-round estimates of missed farms 4/	Adjusted number of farms 5/
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Number	Percent	Number		Percent	Number	
Less than $2,500	768,838	67.2	1,144,104	375,266	80.71	331,759	1,100,597
$2,500-4,999	289,983	88.6	327,295	37,312	8.02	32,966	322,949
$5,000-9,999	296,373	91.9	322,495	26,122	5.62	23,101	319,474
$10,000-19,999	310,011	94.2	329,099	19,088	4.11	16,894	326,905
$20,000-39,999	321,771	98.0	328,338	6,567	1.41	5,796	327,567
$40,000-99,999	324,310	98.9	327,917	3,607	0.78	3,206	327,516
$100,000-199,999	101,153	102.0	99,170	-1,983	-0.43	-1,768	99,385
$200,000-499,999	40,034	102.0	39,249	-785	-0.17	-699	39,335
$500,000 and over	11,412	102.0	11,188	-224	-0.05	-206	11,206
All farms	2,463,885	85.7	2,928,855	464,970	100.00	411,049	2,874,934

1/ Based on 1959 definition, for which see footnote to table 1.
2/ Column (4) is obtained by dividing column (3) into column (2).
3/ Column (5) is computed by subtracting column (2) from column (4).
4/ Column (7) is computed by multiplying column (6) by 411,051, the overall missed farms. The overall missed farms is obtained as follows: 411,051=(2,463,855+2,238)/0.857 - 2,238/0.833, where 2,238 is the number of abnormal farms reported in the Census of Agriculture and 0.833 refers to 83.3% of those farms included in the Census.
5/ Column (8) is computed by adding column (7) to column (2).

Appendix table 3--Adjustment process for underenumeration of the 1974 Census of Agriculture data, by farm size

Farm size	Number of farms 1/	Farms included in census	First-round adjustment of number of farms 2/	First-round estimates of missed farms 3/	Total missed farms	Second-round estimates of missed farms 4/	Adjusted number of farms 5/	Number of adjusted abnormal farms 6/	Adjusted number of farms, excluding abnormal farms
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Number	Percent	Number		Percent		Number		
1 to 9 acres	168,925	66.6	253,641	84,716	18.36	75,551	244,476	89	244,387
10 to 49 acres	453,690	68.9	658,476	204,786	44.37	182,583	636,273	176	636,097
50 to 69 acres	160,702	83.5	192,457	31,755	6.88	28,311	189,013	64	188,949
70 to 99 acres	244,494	83.5	292,807	48,313	10.47	43,084	287,578	106	287,472
100-139 acres	235,056	89.8	261,755	26,699	5.78	23,785	258,841	151	258,690
140 to 179 acres	217,826	89.8	242,568	24,742	5.36	22,056	239,882	96	239,786
180 to 219 acres	137,591	89.8	153,219	15,628	5.39	13,950	151,541	94	151,447
220 to 259 acres	118,346	95.8	123,534	5,188	1.12	4,609	122,955	104	122,851
260 to 499 acres	365,369	95.8	381,387	16,018	3.47	14,279	379,648	351	379,297
500 to 999 acres	209,187	99.0	211,300	2,113	0.46	1,893	211,080	378	210,702
1,000 to 1,999 acres	92,712	99.0	93,648	936	0.20	823	93,535	271	93,264
2,000 acres and over	62,225	99.0	62,854	629	0.14	576	62,801	807	61,994
All farms	2,466,123	85.7	2,927,646	461,523	100.00	411,500	2,877,623	2,687	2,874,936

1/ Based on the 1959 definition
2/ Column 4 is obtained by dividing column 3 by column 2.
3/ Column 5 is computed by subtracting column 2 from column 4.
4/ Column 7 is computed by multiplying column 6 by 411,500; the overall missed farms is obtained as follows: 411,500 = (2,466,123/0.857) - 2,466,123.
5/ Column 8 is computed by adding column 7 to column 2.
6/ Number of abnormal farms divided by its inclusion factor, 0.833.

APPENDIX B

Estimated Simple Trend Equations by Size Class

Appendix table 4--Estimated simple trend equations by average size: 1959, 1964, 1969, 1974 1/

Size of farm	Estimated trend equations	R^2
1-99 acres	$\ln FN^1 = 7.658 - 0.115T$ (192.57) (-7.94)	0.969
100-219 acres	$\ln FN^2 = 7.101 - 0.155T$ (1489.62) (-59.27)	0.9997
220-499 acres	$\ln FN^3 = 6.707 - 0.117T$ (171.27) (-8.16)	0.971
500-999 acres	$\ln FN^4 = 5.402 - 0.0087T$ (140.02) (-0.62)	0.159
1,000-1,999 acres	$\ln FN^5 = 4.423 + 0.029T$ (251.45) (4.55)	0.912
2,000 acres and over	$\ln FN^6 = 4.112 - 0.0004T$ (131.38) (-0.033)	0.000.5

1/ The time variable (T) is: 1959 = 1, 1964 = 2, etc; R^2 is the coefficient of determination. Figures in parentheses are t ratios.

Appendix table 5--Estimated simple trend equations by sales class: 1959, 1964, 1969, 1974 1/

Sales class	Estimated trend equations	R^2
Less than $2,500	$\ln FN^1 = 7.752 - 0.179T$ (146.09) (9.23)	0.977
$2,500-$4,999	$\ln FN^2 = 6.663 - 0.217T$ (81.40) (-7.26)	0.964
$5,000-$9,999	$\ln FN^3 = 6.779 - 0.253T$ (2537.51) (-259.83)	1.000
$10,000-$19,999	$\ln FN^4 = 6.405 - 0.145T$ (78.54) (-4.86)	0.922
$20,000-$39,999	$\ln FN^5 = 5.381 + 0.325 \ln T$ (111.22) (6.38)	0.953
$40,000-$99,999	$\ln FN^6 = 4.312 + 0.905 \ln T$ (17.71) (3.54)	0.862
$100,000-$199,999	$\ln FN^7 = 2.483 + 1.254 \ln T$ (6.52) (3.13)	0.830
$200,000-499,999	$\ln FN^8 = 1.358 + 1.382 \ln T$ (3.43) (3.32)	0.846
$500,000 and over	$\ln FN^9 = 0.079 + 1.404 \ln T$ (0.260) (4.574)	0.913

1/ The time variable (T) is: 1959 = 1, 1964 = 2, etc; R^2 is the coefficient of determine. Figures in parentheses are t ratios.

APPENDIX C

Adjustments for Age Cohort Projections

Several adjustments were necessary in order to use the census data within the age cohort framework to project the total farm numbers by size. These adjustments are summarized in appendix table 6.

The least adjustment was required for the 1964 sales distribution where only estimated missed farms were added to the census published data. These missed farms were published in Evaluation of Coverage (24), which presented the data by age group, acre size, and sales. Therefore, it was necessary to establish the numbers in each cell. The estimated number (E) was determined by the formula, $E_{ij} = N_{i.}N_{j.}/N$ for the i,j th cell. Where $N_{i.}$, $N_{j.}$, and N represent the totals of the i th row, the j th column, and the grand total. This formula was also used for the abnormal farm matrix (line 3, appendix table 5), the 1974 farms with sales of less than $1,000 (line 4), and the corporate and other (line 5). The age distribution for corporate and other operations was obtained from the 1969 Census of Agriculture.

Another adjustment was made to the sales data to remove the impact of price inflation for farm commodities. The sales distribution was deflated for each age group as described in the data adjustment section, except that 1964 constant prices were used. The projections were made in constant prices, then reinflated to the expected price levels as described in the data adjustment section. A log polynomial of the 4th degree was used. A peculiar kink developed at the lower end of the size curve that caused a rapid increase in small farms when the curve was shifted for reinflation. This did not correspond to the historical shape in 1964 or 1974. The fit did not improve by changing the degree of polynomial. Therefore, the data were plotted on log paper and smoothed for the lower sales classes in each age group.

The cohort ratio shown in tables 24 and 25, when multiplied by the base period data, resulted in projections where the individual cells in the row summed to more than the row total except for farm operators younger than 25 years old. The row total was obtained by multiplying the age group total by the cohort ratio for the age group in the last column in tables 24 and 25. The individual projected numbers for each cell was forced to equal the projected totals for each age group (see appendix table 7 for adjustment factors).

Appendix table 6--Adjustments to census data and projects for acres and sales, 1964 and 1974

Item	Acres			Sales		
	1964	1974	Projections	1964	1974	Projections
1. Estimated missed farms	1/	x		1/	x	
2. Estimated age-size matrix for missed farms	x			x		
3. Estimated age-size for abnormal farms in order to subtact them	x	x				
4. Farms with sales of less than $1,000 not included in 1974		x			x	
5. Corporations and others without opertor age-distributed by size		x			x	
6. Deflation with decumulative log polynomial curve		x				
7. Reinflation to current prices			x			x
8. Adjust cell total to equal cohort total			2/ x			2/ x

1/ 401,000 farms reported in Census Evaluation Coverage by Age, Acres and Sales Distribution.
2/ See appendix table 4 for amount of adjustment required.

Appendix table 7--Ratios of adjustment used for acre and sale projection by age

Age	Acres			Sales		
	1984	1994	2004	1984	1994	2004
	Ratios					
Less than 25	0.999	0.991	0.993	1.028	1.050	1.040
25-34	.983	.967	.958	.861	.861	.790
35-44	.984	.979	.963	.915	.915	.845
45-54	.987	.977	.980	.931	.931	.890
55-64	.991	.980	.972	.943	.943	.919
65 and older	.999	.991	.975	.978	.984	.952

*U.S. GOVERNMENT PRINTING OFFICE : 1980 O-310-945/ESCS-218

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