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THE EFFECTS OF INDUSTRIALIZATION ON FARM INCOME DISTRIBUTION AND FARM NUMBERS IN NEW ENGLAND

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ABSTRACT

Affected by industrialization, agriculture in New England adapts to economic changes. Farms have become either large commercial units or small part time farms. Distributions of farm income have changed from an inverted-J distribution to a U-shaped distribution in the past three decades. Farm income grows slower and shows a larger dispersion in urban counties than in rural counties. Analyses of census data support the hypotheses (1) that farm income is lognormally distributed and (2) that industrialization has a complementary effect on agriculture while growth of urbanization essentially reduces farm numbers mostly in middle income classes.

INTRODUCTION

In the course of a little more than 100 years, changes in the New England area have been spectacular and striking -- from a rural and self-sufficient agriculture to a complex, urban and industrialized economy. Today New England is known more for its cities and industries than for its farms.

In the process of industrialization, many economic transformations and adjustments have occurred in the New England economy. Agriculture, which is affected by industrial development, has been subject to drastic economic changes. As Ruttan emphasized, the interactions between the farm and nonfarm sectors of the economy take place in different markets for agricultural input factors and output products. In the land market, New England lost 14,000,000 acres of farm land between 1900 and 1970. From 1950 to 1974, the number of farms decreased from 59,270 covering 14,589,526 acres to 22,696 farms with 4,800,579 acres. Through the labor market, the labor force engaged in the farm sector has decreased substantially while the labor force engaged in manufacturing and service occupations has risen steadily. The capital market has supplied farms with the investment needed in order to benefit from technological changes associated with the type of specialized farming in the area. In the output market, dairy, vegetable, and horticulture farms supply highly perishable products to meet the needs of the local urban population. Adapting to urbanization and industrialization, farms increase their income and move to higher income classes. However, farms unable to adapt to economic changes are most likely to be affected negatively. Therefore, farms have decreased in number while those remaining have become either large commercial units or small part time farms.

In order to assess the future of agriculture in New England, the trend of agricultural activity in the region for the past three decades is studied and the factors affecting agriculture identified. In particular, the objectives of this paper are (1) to examine the changes in gross farm income for 65 counties from 1950 through 1974, (2) to relate the declining total farm income with some basic economic factors, and (3) to forecast the distribution of farms in farm income classes through 1985. In achieving objective one, the lognormal and gamma density functions (Thurow, and Salem and Mount) are used to represent the distribution of farms in different income intervals for each county in each census year. The change in income distributions over space and time are then studied. Objective two is completed by regressing the farm numbers in each income class on various indexes which show degrees of urbanization and industrialization. The trends of the explanatory variables are predicted and the future farm distributions forecast through 1985 to achieve the third objective.

FARM INCOME AS AN INDICATOR OF AGRICULTURAL ACTIVITIES

Gross farm income is used as an indicator of agricultural activity in New England. The real regional gross farm income in 1950 was $765,045,000 and in 1974 was $634,476,000 as indicated in Table 1. The declining regional gross farm income follows the reduction in farm land and farm labor. Farm land, 14,589,526 acres in 1950, fell to 4,800,579 acres in 1974. Farm labor in 1950 totaled 153,676 and by 1974 had been reduced to only 32,183. The changes are consistent with the increased industrialization and urbanization.

To gain insight into farm income changes over time, census data of farm income distribution for each county of New England, as well as the region, are used to fit the lognormal and gamma probability density functions. Parameter estimates are obtained by the methods of maximum likelihood, least squares, and the minimum chi-square as described in McDonald and Ransom, and the nonlinear optimizing computer program, GQOPT obtained from Princeton University. Due to local optima, the results of maximum likelihood and minimum chi-square are inconsistent. Therefore, only the least squares results are reported in Table 2.

In using the lognormal distribution, the logarithm of farm income is assumed to be normally distributed with mean μ and variance σ^2. In particular, the lognormal density function is

$$f(x) = \frac{1}{\sqrt{2\pi}\,\sigma} - 1/2 \left(\frac{\log x - \mu}{\sigma}\right)^2$$

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Table 1. Regional and Farm Income, Acres in Farms and Farm Labor Force, New England, 1950-1974.

Year	Regional Personal Income[a] (millions $)		Farm Income[b] ($1,000)		Land (acres)	Farm Labor Force (people)
	Nominal	Real[c]	Nominal	Real[c]		
1950	15,180	21,842	531,706	765,045	14,589,526	153,676
1954	20,200	26,474	535,177	701,411	11,120,920	115,103
1959	25,500	30,106	592,972	700,085	9,316,356	74,869
1964	33,800	36,462	712,985	769,132	7,744,494	58,488
1969	50,400	45,818	683,316	621,196	5,350,681	39,959
1974	73,500	45,342	1,028,486	634,476	4,800,579	32,183

[a] From U.S. Statistical Abstracts.

[b] Farm income is the market value of all agricultural products sold, from Agriculture Census 1950-1974.

[c] Adjusted by the Regional Consumer Price Index (1967 = 100). The indices are 69.5, 76.3, 84.7, 92.7, 110.0 and 162.1 from 1950 to 1974 respectively for each of the years shown in the table.

Table 2. Least Squares Estimates of Farm Income Distribution Parameters.

Census Year	Lognormal				Gamma			
	μ	σ	Gini	χ^2	α	λ	Gini	χ^2
	Average by Counties							
1950	1.43	1.05	0.43	11.95	2.10	0.34	0.37	36.14
1954	1.50	1.12	0.47	12.31	2.20	0.35	0.36	52.69
1959	1.82	1.13	0.48	9.38	2.35	0.31	0.36	45.16
1964	1.55	1.46	0.52	10.73	2.09	0.22	0.37	295.87
1969	1.17	1.79	0.67	7.09	2.02	0.21	0.37	266.31
1974	1.13	1.97	0.73	3.42	1.88	0.18	0.39	255.14
	Aggregate for New England							
1950	1.70	0.95	0.50	994.35	2.11	0.15	0.36	2739.79
1954	1.90	1.08	0.55	60.72	2.25	0.17	0.36	4578.91
1959	2.05	1.12	0.57	19.48	2.32	0.17	0.35	3991.75
1964	1.70	1.52	0.72	12.34	2.10	0.21	0.37	2972.46
1969	1.51	1.52	0.81	10.63	2.02	0.17	0.37	4815.55
1974	1.50	1.52	0.83	11.40	2.22	0.15	0.36	3548.13

Note: In estimating the parameters, the input intervals are in thousand dollars. Thus, for example, the mean for 1974 for the gamma function is $\alpha/\lambda = 2.22/0.15 = 14.8$ or $14,800.

where x is income. Therefore large values of the estimates of μ indicates high farm income and the large value of the estimate of σ indicates high degree of unequal income distribution.

For the gamma density, the function is

$$f(x) = \frac{\lambda^{\alpha}}{\Gamma(\alpha)} x^{\alpha-1} e^{-\lambda x}$$

The parameter α is related to a measure of inequality. A large value of α indicates less inequality since the coefficient of variation of the gamma distribution is $(1/\sqrt{\alpha})$ x 100 percent, which is the percentage ratio of the standard deviation $\sqrt{\alpha}/\lambda$ and the mean, α/λ, where λ is the scale parameter.

A Gini coefficient of concentration (or Gini coefficient for short) is the ratio of the area between the Lorenz curve and the diagonal to the entire triangular area under the diagonal (see Aitchison and Brown). The Lorenz curve shows the relationship between the percent of total income and the percent of population. The Lorenz curve is a convex curve and Gini coefficient increases as the degree of income inequality increases. Gini coefficients range between 0 and 1. The Gini coefficients reported in Table 2 show increasing farm income inequality in recent years as the degree of industrialization in the area increases.

In general, statistical test results show that farm income distribution in the 65 New England counties is distributed as a lognormal density and not a gamma density. The chi-square goodness-of-fit test shows the average of chi-square values for each census year from 1950 to 1974 ranges from 3.42 to 12.31 for the lognormal and 36.14 to 295.87 for the gamma. The table value is 13.28 for 4 degrees of freedom at 99 percent significance level, since five income classes (see Table 3) are used in the fitting. The chi-square values for the gamma density are larger than the table value and we reject the hypothesis that they are gamma distributed.

At the aggregate level, the chi-square value in each census year is relatively higher than at

Table 3. Number of Farms in New England, 1950-1974 and Their Forecast for 1979-1985.

Year	Gross Farm Income $ 0 - $2,499	$2,500- $4,999	$5,000- $9,999	$10,000- $19,999	$20,000 & over	Total
1950	24,312	14,035	14,385	10,990	3,660	67,382
1954	18,115	10,974	12,913	10,596	3,865	56,463
1959	16,487	6,402	8,801	9,662	8,576	49,928
1964	11,690	3,794	5,223	6,383	9,757	36,847
1969	11,653	2,641	2,693	4,008	9,343	30,338
1974	7,127	1,962	2,031	2,374	10,023	23,517
			Forecast			
1979	7,354	1,065	1,327	2,475	7,695	19,916
1980	7,177	942	1,181	2,354	7,744	19,398
1981	7,014	831	1,051	2,248	7,805	18,949
1982	6,862	729	931	2,148	7,871	18,541
1983	6,722	638	827	2,061	7,946	18,194
1984	6,592	559	737	1,985	8,031	17,904
1985	6,472	489	659	1,919	8,126	17,665

Note: Nantucket and Suffolk Counties of Massachusetts are excluded due to lack of data in some census years. The numbers do not include part retirement, residential and institutional farms. Detailed data are obtained from New England Regional Office, Bureau of Census, U.S. Department of Commerce.

the county level. However, the hypothesis that the regional farm income distribution is lognormally distributed for 1964, 1969, and 1974, cannot be rejected. For the early three census years, it is rejected. Gamma density is also rejected at the aggregate level.

The results of lognormal distribution indicate that the trend of changes in farm income over the last three decades increases from 1950 to 1959 and then decreases through 1974. Since these estimates are based on income data in current dollars, the declining trend would be more significant if the deflated data are used.

Examination of the cross sectional county data shows declining farm income to be more significant for counties near the industrialized or urban center. The decline is especially noticeable for the Connecticut Valley from Hartford to New Haven, Boston metropolitan area, and the Providence area. Farm income density maps for 1950 and 1974 are shown in Figures 1 and 2 to contrast the change in real gross farm income.[1]

FARM DISTRIBUTION BY INCOME CLASS

The number of farms in each income class shows the growth and exit of farms. For the past six census years, the number of farms in the five income classes are given in Table 3. Although the number of farms with incomes of $2,500 or more should be comparable among census years, farms with incomes less than $2,500 are not comparable because of the changing definition of farms. For example, the requirement of 10 acres and $250 income in 1959 was changed in 1964 to 10 acres and $250 income or farms with income of more than $250 but less than 10 acres. The number of farms in the income class $20,000 or more increases while the number in other classes decreases. The actual income distribution tends to be U-shaped in the last three census years.

Although technology changes, comparative advantage of production, and unequal endowments of natural and human resources might have affected farm numbers and size, the effect of urban-industrial complex is emphasized in this study. It is hypothesized that industrialization in New England provides a variety of nonfarm employment opportunities for the farm population, which causes farm labor to out-migrate and farms either to adopt capital intensive farming or become small part-time farms. Accompanying industrialization is urbanization, which competes with farms for land for residence, plant sites, shopping malls, highways, and recreational parks. When a portion of farm land is transferred to other uses, the farm either decreases in size or may integrate the remaining land with adjacent farms to form a larger farm. Therefore, the number of farms in each income class is specified to be a function of the percent of farm population employed in nonfarm work,[2] the number of farms whose total family income from off-farm work and other sources exceeds agricultural sales,[3] the per capita payroll from manufacturing,[4], and the percent of nonfarm population in an area.[5] These variables are often used in studying the impact of urban-industrial development on agriculture. (See Nicholls, Tang, Ruttan, Sisler, Sinclair, Sale, Schriore, Bogue and Harris, Kingsley and Herts, and Elsner and Hoch.) The percent of nonfarm employment, which represents an index of the relative importance of nonfarm employment to the rural farm population, is expected to have positive relationship with the number of large size farms. Number of farms with off-farm income exceeding agricultural sales, indicates industrial opportunities for farmers in small farms, and is expected to have a positive relationship with the number of small farms. The per capita payroll from manufacturing, which measures the degree of industrial development and at the same time shows the strength of purchasing power of the urban population's demand for agricultural products, is expected to have a positive relationship with the number of farms in all income classes. The percent of nonfarm to total population, which indicates the degree of relative urbanization, is expected to affect negatively the number of farms.

The results of regression analysis are given in Table 4. The parameter estimates are in general significant and exhibit interesting patterns. The percent of nonfarm to total population has a significant negative effect on farms whose incomes are between $2,500 and $10,000, and has a distinct positive effect on the largest income class. However, the effects on farms with incomes between $10,000 to $20,000, or less than $2,500 are not significant. The per capita manufacturing payroll variable has significant effects on farms of all income classes and with greatest magnitude on the highest income class farms. Percent of nonfarm employment affects the

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[1] For the purpose of showing geographical differences eight classes were used instead of the five for least squares fitting, shown in Table 3. Class intervals also differ from those shown in Table 3. The total income for each county is in real income that is deflated by the Regional Consumer Price Index (1967 = 100).

[2] Compiled from Population Characteristics, USDC, Farm Labor Reports, ERS, USDA, The Regional Economic Information System, Bureau of Economic Analysis, and Current Employment Statistics Program, Bureau of Labor Statistics, U.S.Dept. of Labor and Employment and Training Administration.

[3] State and County Data, Census of Agriculture, USDC.

[4] Available as the payroll in the first quarter in County Business Patterns, Bureau of Census, USDC.

[5] Decennial Census of Population, USDC, and Population Estimates and Projections, Series P-25, Bureau of Census, and unpublished data from the Regional Office, Bureau of Census, Boston.

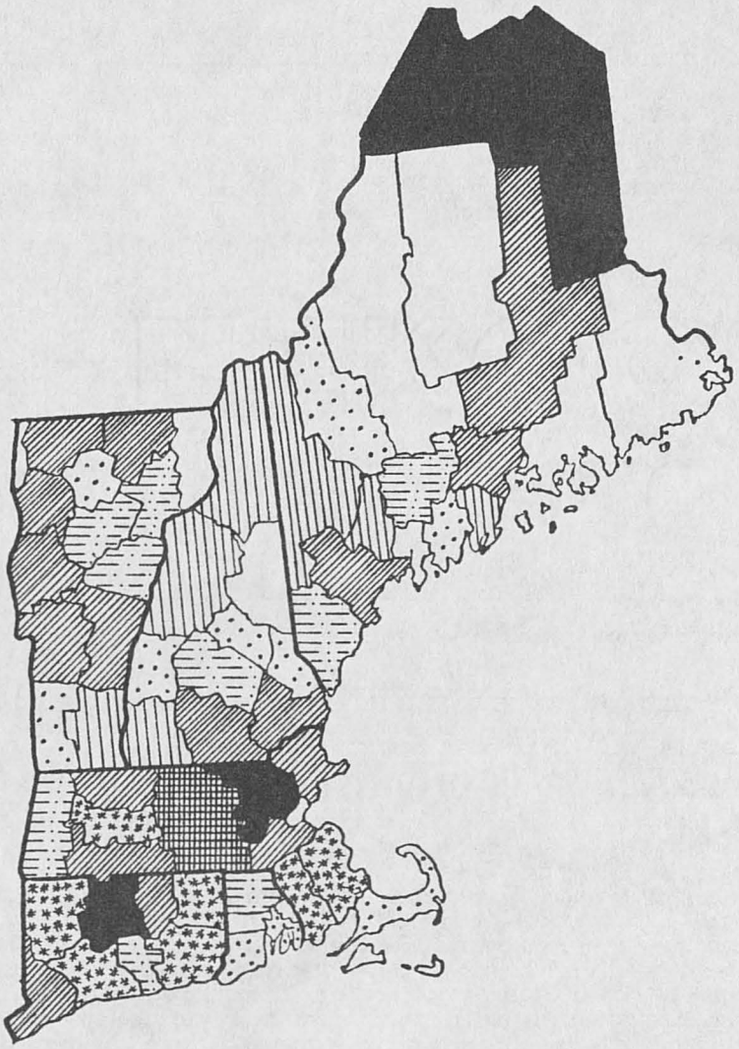

Figure 1. Total Gross Farm Income, 1950

Income Intervals
(in 1967 dollars, 1,000)

$ 0 - $ 2,999
$ 3,000 - $ 4,999
$ 5,000 - $ 6,999
$ 7,000 - $ 9,999
$10,000 - $14,999
$15,000 - $19,999
$20,000 - $29,999
$30,000 and over

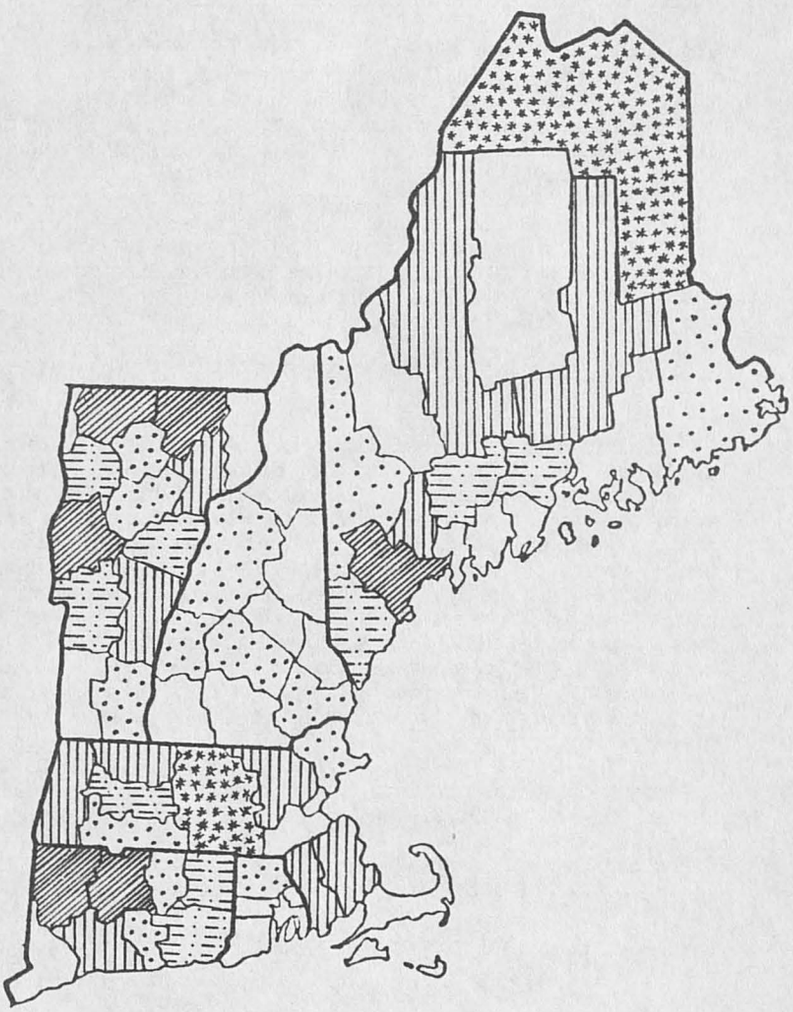

Figure 2. Total Gross Farm Income, 1974

Income Intervals
(in 1967 dollars, 1,000)

$ 0 - $ 2,999
$ 3,000 - $ 4,999
$ 5,000 - $ 6,999
$ 7,000 - $ 9,999
$10,000 - $14,999
$15,000 - $19,999

Table 4. The Effects of Industrial-Urban Factors on the Number of Farms in Income Classes at the County Level.

Income Classes	Intercept	Percent of Non-Farm to Total Population (percent)	Quarterly Per Capita Mfg. Payroll ($1,000)	Percent of Nonfarm Employment (percent)	Farms With Off-Farm Income Exceeding Agr. Sales (number)	R^2	F	Avg. No. of Farms
$ 0 - $ 2,499	-32.7995	0.7168 (0.6283)	0.7563 (0.3801)*	0.8448 (0.4544)	0.4455 (0.0158)**	0.68	201.44	229.19
$ 2,500- $ 4,999	80.8810	-1.8060 (0.4399)**	2.0731 (0.6235)**	2.2592 (0.3181)**	0.2487 (0.0111)**	0.65	185.41	102.07
$ 5,000- $ 9,999	8.2694	-1.7786 (0.6633)**	3.3556 (0.9401)**	4.1826 (0.4797)**	0.2518 (0.0167)**	0.54	113.36	118.07
$10,000- $19,999	-243.0302	1.0783 (0.8001)	2.8642 (1.1340)*	3.9919 (0.5782)**	0.2227 (0.0202)**	0.33	48.94	112.85
$20,000 & over	-387.6873	3.7093 (1.0387)**	5.1307 (1.4722)**	3.1171 (0.7512)**	0.0389 (0.0262)	0.11	11.43	115.96
Average	1	92.9864	2.3772	42.5910	353.6923			

Note: One asterisk denotes 5 percent significance level and two asterisks denote 1 percent significance level.

number of farms in the classes with incomes higher than $2,500 at the 99 percent confidence level, but does not affect farms with less than $2,500 income. Finally, the number of farms where total family income from off-farm work and other sources exceeds agricultural sales has uniformly significant positive effects on farms with incomes of less than $20,000.

The regression results support the hypothesis that industrialization has complementary effects on the number of farms in different income classes while urbanization has decreased the number of farms in the medium to small size farms and increased the largest size farms.

FORECAST OF FARM NUMBERS

Given the regression equations, the future distributions of number of farms can be forecast by income class. To forecast farm distributions, it is first necessary to forecast the future trend of the explanatory variables. Instead of dealing with 65 trends, the time series of six census years, obtained by averaging the values of 65 counties (Table 5), is fitted to the growth trend function for each industrialization indicator. Exponential functions are used because most variables are in percentages that cannot exceed 100 percent. With t=0 for 1950 and t=4 for 1954, etc., the results of the estimated equations are given as follows:

Percent of nonfarm to total population
$= 100 - (13.8949)(0.9280)^t$; $R^2 = 0.9939$

Per capita manufacturing payroll
$= (1.0228)(1.0623)^t$; $R^2 = 0.9636$

Percent of nonfarm employment
$= (48.7724)(0.9880)^t$; $R^2 = 0.9272$

Number of farms with off-farm income farms
$= (657.9562)(0.9351)^t$; $R^2 = 0.9887$

The R^2 reported above are the results of the least squares estimation on the semi-logarithmic functions of the trend, i.e., log y = a + bt. The trends of the explanatory variables show that the percent of nonfarm to total population is increasing and will cause farm distribution by income classes to be U-shaped. Since the percentage cannot exceed 100, the percent of farm to total population is fitted to a trend line and its complement to 100 percent is used as a forecast of the percent of nonfarm to total population. The farm population is decreasing 7.2 percent annually. Manufacturing payroll per capita is increasing 6.23 percent annually, and the percent of nonfarm employment is decreasing 1.2 percent annually. The number of farms whose major income is from off-farm income is also decreasing at approximately 6.5 percent annually (Table 5).

The trend values of the explanatory variables permit forecasting the number of farms in each income class as reported in the last seven rows of Table 3. As expected, the number of farms in each size class is decreasing and the distributions become distinctly U-shaped. The numbers in Table 3 do not include the part retirement, residential and abnormal farms.

SUMMARY AND CONCLUSION

Farm income distribution, income dispersion and number of farms are changing rapidly in New

Table 5. Indicators of Industrializations and Urbanization, Average of 65 Counties in New England.

Year	Percent of Nonfarm to Total Population (percent)	Quarterly Per Capita Mfg. Payroll ($1,000)	Percent of Nonfarm Employment (percent)	Farms With Off-Farm Income Exceeding Agr. Sales (number)
	Observed Average Per County			
1950	85.36	1.0924	50.62	636.63
1954	89.78	1.4048	46.37	505.49
1959	93.27	1.5855	41.68	376.82
1964	95.16	2.0757	40.83	272.32
1969	96.84	3.1515	38.45	194.05
1974	97.51	4.9533	37.59	136.84
	Forecast			
1979	98.41	5.9054	34.35	94.08
1980	98.52	6.2734	33.93	87.98
1981	98.63	6.6644	33.53	82.27
1982	98.73	7.0797	33.12	76.93
1983	98.82	7.5210	32.72	71.94
1984	98.90	7.9897	32.33	67.28
1985	98.98	8.4877	31.94	62.91

England agriculture. The gross farm income distribution can be described by a lognormal density function at the county level. The estimated central tendencies of the lognormal density function show the trend of distribution in the last three decades. The dispersion measure of the distribution and Gini coefficient also describe the geographical differences of growth and declining of agriculture in the sense that farm income grows slower with larger dispersion in urban counties than in rural counties.

Farm income per farm is increasing but the total number of farms is decreasing. To measure the effects of industrialization and urbanization on the number of farms, the number of farms in each income class is regressed on four urban-industrial factors. The results show that industrialization has a complementary effect on agriculture while growth of urbanization essentially reduces farm numbers mostly in the middle income classes.

With regression equations of number of farms in each income class, the number of farms are forecast for the years 1979 through 1985. The number of farms is declining, particularly the farms with income between $10,000 and $20,000. However, total gross farm income in the area increases and the number of farms also increases in the highest income class.

Farms unable to reorganize farm resources are most likely to be affected negatively by urbanization which accompanies industrialization. Consequently, the number of farms in the middle classes decreases to form a U-shaped distribution and therefore income inequality increases substantially. The U-shaped distribution of farms by income class, resulting from urban-industrial development, has perhaps been influenced by the U.S. policies and the unique setting of New England agriculture.

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